The Foundry Trade Journal

AND PATTERN MAKER.

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Contents.

Notes and Comments	405
Reflections from the Fettling Shop of a Steel Foundry	407
British Foundrymen's Association	411
United Kingdom Furnace Statistics, 1916	411
Emergency Jobs	412
Some Geological Characters of Moulding Sands	414
Common Sources of Error in Castings	419
Electric Furnaces in United States Steel Foundries	422
Moulding Water-Ballast Rollers	424
Refractory Material	427
Electric Furnaces for Melting Ferro	428
Metallurgy of Cast Iron	428
Roll Scale as a Factor in the Bessemer Process	429
Refractories for Steel Furnaces	432
Wright-Morgan Furnaces	434
Furnace Charging Machine	435
Correspondence	436
Munition Workers' Health	437
Trade Talk	438
Pig-iron Prices	440
Deaths	440
Personal	442
Legal	442
New Companies	444
Monthly Price List	446

NOTES AND COMMENTS.

Effect of Silicon on Cast Iron.

We are afraid that this discussion (see page 436) will get no "forrader," no matter how long it continues, since the contestants persistently employ certain phrases in different senses. In the first place, we cannot accept Mr. Rolfe's contention in this issue that Mr. Adamson is wrong in stating that "silicon content does not control combined carbon, etc., unless he makes certain qualifications." The fact has long been established (and already admitted by Mr. Rolfe) that the influence of silicon is conditional on other factors. If it were the controlling element its effect would be positive, and not conditional. The disagreement in progress between the two writers is merely one of phraseology and not one of fact, and arises from the abuse or loose usage of terms. In the interests of clear discussion we strongly deprecate the use of the term "control" to cover conditional influence, and consider that if the effect of silicon under varying conditions is being pleaded it is for that protagonist (and not Mr. Adamson) to make the qualifications if he will insist on using the term "control" to describe "influence." The fact cannot be denied that the use of the loose phrase "silicon control," and the publication of researches by many men illustrating the influence of varying silicon under given conditions, have led practical men into the error of believing that so long as the silicon content of an iron is right nothing else much matters.

Mr. Rolfe does not assist the discussion when he states that the issue is "whether silicon exercises no control over the distribution of carbon in cast iron . . . . or whether it exercises a qualified control." The quotation he gives from Dr. Hadfield's book in which the *influence* of silicon is admitted to be conditional, only emphasises our conclusion that the dispute under discussion is not one of fact but of phrase. Even if we were not already aware of it, the conclusion is obvious from the correspondence already published, that the two writers are in substantial agreement, save that Mr. Adamson in his original paper set out to insist that silicon exercised not control but influence, while Mr. Rolfe prefers the term "conditional control" to describe influence in a definite direction and of definite quantity under given conditions. Discussion on this basis is not very profitable, nor does it tend to any sort of decision as a proper discussion should. Such discussions, however, do certainly prove the necessity for more explicit expression by writers on scientific and technical matters. Careless phraseology only leads to careless application of scientific facts and conclusions, and opens the way to error and pitfalls for the practical man, who accepts a general phrase on its face value and adopts it as implying an axiom.

Reverting to the question at issue, one might be inclined to accept the use of the term "control" in relation to the effect of carbon con-

tent, nature and distribution on the physical properties of cast iron; for, regardless of the contents of other ordinary constitutents within broad limits, the physical properties of iron are dependent on the carbon, its amount, nature and distribution—and by "nature" we imply not merely whether in combined or in graphitic form, but also the quality or condition and size of that graphite. Since the amounts of other elements present (including silicon) may vary considerably, and the same carbon content and distribution be got, obviously the latter is not determined or controlled by any one constitutent of the iron or one condition of manufacture.

Carbon, then, may be said to control the physical properties of iron, if control can really be credited to a constituent whose own state is determined by the sum total of all the conditions of manufacture, composition of furnace burden and circumstances of casting into pig. To be academically accurate, no constituent *controls* the properties of cast iron, though carbon may be said to afford a correct index to the inherent properties of the alloy, for the determining influences act through the carbon to produce those properties. Because those controlling influences generally include silicon content (which itself is determined by other influences) we are often tempted to incorrectly name silicon a controller; but it is not such, since its effect is only constant or proportionate to its quantity when other conditions are regular. The fact that the effect of silicon can be over-ruled by other variables shows that it exerts influence but not control; and the fact that the distribution and quality of the carbon content are governed by factors other than the quantity of carbon present, discounts the use of the term control in connection with carbon. In fact, it is rather dangerous to talk of controllers at all, particularly at present, when the mention of the word is sure to give rise to heated expressions of opinion on controllers generally.

Overtime and Industrial Fatigue.

The question of industrial fatigue has recently been studied more scientifically; numerous reports have been made by investigators acting on behalf of the Ministry of Munitions, the Home Office, and the British Association. These are admirably summarised by Professor H. J. Spooner, C.E., of the Polytechnic School of Engineering.* In the war trades, he observes, it was found after a time that the output was far from being proportional to the number of hours worked, "particularly when the hours were much above the normal," and much time was lost through illness and other causes. Many experienced employers believed all along that the new policy of "driving" was a mistake. Many of the most successful employers are convinced from their own experience that a long working day does not pay. Sir Robert Hadfield, for instance, explains that his own firm, Messrs. Hadfields, Ltd., of Sheffield, "have for the past twenty-three years adopted a forty-eight working hours' week, and have found it a decided advantage." In the early period of the war, he says:—

"Our industrial establishment, employing some 15,000 hands, never shut down except for a few days; that is, excepting one or two holidays, we ran clean through for eighteen months without a stop from Monday morning until Sunday night; but it did not pay."

More recently and with the permission of the Ministry of Munitions, Messrs. Hadfields knocked off Sunday work, with the result that their output has been equally great.

A good, healthy worker can work time and a-half over a fairly long period without a sensible decrease of production if all the conditions are favourable; but continuous overtime inevitably leads to a falling-off. Fatigue, it must be understood, is not wholly or perhaps even mainly a muscular thing. People who work with their brains rather than with their hands have always known this; indeed, their usual way of resting their brains is to exercise their muscles. It does not appear at first sight to apply to manual labour, but even in the case of factory workers Professor Kent maintains that "the seat of fatigue is rather on the nervous than the muscular side"; that noise, worry, flickering lights, and an atmosphere of fussiness create a feeling of fatigue. Moreover, fatigue in the sense of a diminished capacity for doing work is often present before the worker is himself aware of it. Indeed, as one Home Office report says:—

In its essential features the fatigue of all alike has been found to depend not upon the simple using up—"exhaustion"—of the substances supplying the chemical energy which is liberated during work, but upon the accumulation within the living elements of the products of the chemical changes involved.

In other words, it is not the failure of fuel in the steam engine so much as a clogging of the wheels by dirt. The human body is a machine, and a very ingenious machine, too. All machines require rest, cleaning, and the replacement of worn parts. One deduction from this analogy is that short interruptions of work, amounting to a few minutes each, cannot be considered as the equivalent of an interval of rest equal to their sum; on the contrary, they may even add to the fatigue, like the idle running of an engine.

Scientific investigation has discovered various laws governing the amount of work which a man can do—*e.g.*, fatigue from handling additional weights increases with the weight; but not in direct proportion. "When the correct weight of the unit to be handled has been determined, the additional weight will cause fatigue greater in proportion than the extra weight handled." Consequently, in all heavy manual work periods of rest must be prescribed. In handling pig-iron, for instance, it is found that a first-class workman can only be under load 43 per cent. of the day; but in handling a half pig he can be under load 58 per cent. of the day. The best length of working day varies in different trades; an industry carried on in a town may require a shorter day than the same industry carried on in the country. Actual tests have proved that a shorter day may give a larger output, although the worker himself may be quite unaware of the fact. This applies, of course, particularly to skilled work, which demands freshness and vigour. When the output depends mainly on the machine, work may be performed sufficiently well by tired men. Generally speaking, a five hours' spell is a mistake. In most trades, however, it will be found that the actual time a man works is only a small percentage of the total length of the shift.

* "Industrial Fatigue in its Relation to Maximum Output" Published by the Co-partnership Publishers, Ltd., 6, Bloomsbury Square, W.C.

Reflections from the Fettling Shop of a Steel Foundry.

A Paper, entitled "A Few Reflections from the Fettling Shop of a Steel Foundry," was read before the Sheffield Branch of the British Foundrymen's Association recently by Mr. John Watson, steel foundry manager to Messrs. Cammell, Laird & Company, Limited, Sheffield. The Paper was as follows:—

It is important at the outset to note that I am speaking from the standpoint of a jobbing steel foundry using open-hearth acid steel, for although first principles remain the same in jobbing as in repetition shops, cause and effect vary. For instance, we all recognise that one of the factors in foundry efficiency is a regular daily cast of a certain tonnage of castings. In a repetition shop this is a comparatively easy matter, as charges can be made up easily and small melting units are usually employed. In a jobbing shop the run of work may involve a variety of test specifications with their corresponding variety of analyses, and often it is a matter of great difficulty to assemble a daily cast to take the output of the large furnaces working in a jobbing foundry using acid open-hearth steel. This is a point on which close collaboration between the selling and manufacturing sides can greatly help the foundry efficiency.

The fettling shop is the Cinderella to its more favoured sister, the moulding shop, and its open face is the mirror that reflects all the blemishes of that sister's vaunted superiority. I once heard a fettler say that if it wasn't for fettlers half the moulders would be out of a job. He did not mean the ordinary dresser, but the super-dresser, who, in Sheffield, is paid 9d. per hour, plus extras, and is known by the euphonious name of the "knocker-up." This particular gentleman, coupled with the electric welder, is a standing monument to the inefficiency of the moulding shop.

Most of you will have heard of Euclid's famous axiom, "A straight line is the shortest distance between two points." Now in a steel foundry we have two such points—the order book and the loading bank—and the efficiency of our foundry depends on how near we can approximate to that straight line between these two points; but as we are not crows we have to modify our axiom by the consideration that the shortest distance may be round a corner, and to keep that curve efficient we must always keep before us the factor of continuity of direction—there must be no doubling back over the first track. Just as in our argument a straight line may be a curve, so a curve may be a straight line, and the application of the straight-line curve is, in my opinion, the basis of success in manufacturing.

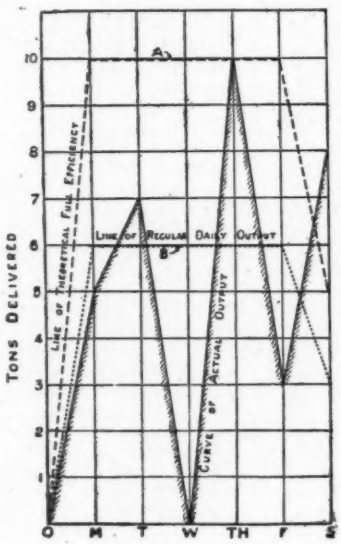


Fig. 1

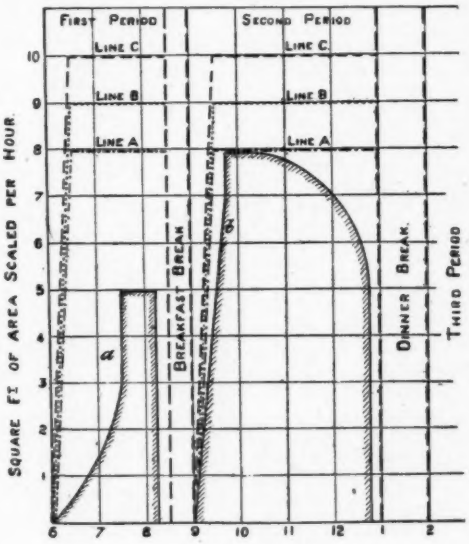


Fig. 2.

It is surprising that the plotting of curves, and the correct solution of their meaning, is not more studied by managers than it is. I know of nothing more illuminating. Take, for instance, the curve of daily production plotted out, say, in tons delivered for each day worked; if you plot such a simple curve you will most probably get something like Fig. 1. Here is a curve showing the fluctuation of daily output, and the problem is to find out why the curve looks like a contour of the Himalaya Mountains, and how it can be made a straight line showing an equal daily distribution of output, as shown by the line A.

Suppose we have a fettling shop designed to finish and deliver 55 tons per week, then on an evenly-balanced output we should deliver 10 tons per day for five days, and five tons on Saturday, and our

theoretical full efficiency line will be the line A. Our actual deliveries, however, are:—Monday, 5 tons; Tuesday, 7 tons; Wednesday, 0 tons; Thursday, 10 tons; Friday, 3 tons; Saturday, 8 tons. We get, on plotting, the shaded line or curve of actual output.

The manager's first problem is to reduce this irregular line to the line B showing regular daily output, and his next to make the line B coincide with the line A; that is what is meant by "push and go" in a steel foundry. An excellent education lies before the man who has never tried to solve this problem.

Let us see how in the solution of this simple curve we can utilise another not quite so simple, but vastly more illuminating. Let us try to find out what is happening between two points on our curve, say, during Tuesday's working hours, by plotting down a curve of the human effort expended in that day's production. In other words, we take the straight line M.T. and diagnose it. You will find great difficulty in plotting this curve, but assuming that we have succeeded, in our datal work jobbing foundry, it will appear like Fig. 2. Here is plotted down the curve of daily effort expended by a hand fettler scaling an annealed steel casting. We will assume that his maximum effort is at the rate of

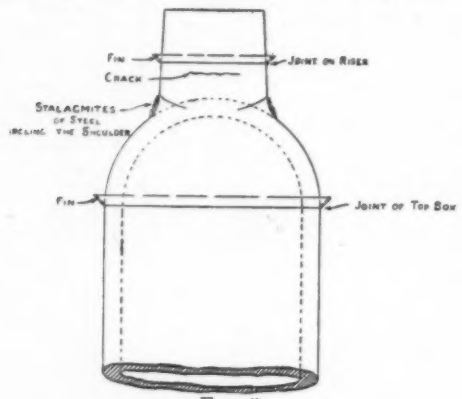


Fig. 3.

8 sq. ft. per hour, then his theoretical line will be the line A. His actual effort, however, only produces the shaded lines shown on each period, and this curve is worth studying.

Let us follow it from 6 o'clock and trace its teaching. The straight line A is the theoretical full efficiency. It is a winter's morning, and the worker moves sluggishly; he is cold and most probably hungry, and his effort curve crawls slowly up to the point *a* about 7.30, when a sharp rise takes place in a few minutes. You will find that at this point the foreman has emerged from the warmth of his cabin, and the solace of his morning pipe and paper, and work goes on steadily with a straight curve to, say, 8.15, when the foreman goes back to his warm cabin and our curve drops sharply to the base line as our worker wanders off to warm his tea can. Then the breakfast break intervenes, and now see the change. The man is fed, he is warm with his hot tea and a smoke in front of the furnace, and his efficiency curve rises sharply to its maximum at about 9.45 a.m., and continues for an hour or so while he is feeling the benefit of his meal. His curve then droops, and again sharply drops when he warders off to look for his dinner basket. The afternoon curve is a reproduction of the after-breakfast curve, except that it droops earlier and faster as the operator tires. The point *b* where there is a short, sharp rise about 9.45 o'clock marks the manager's advent in the shop.

It needs no very hard thinking to read the lesson of this curve. The section No. 1 is absolutely inefficient and wants cutting out, so that our 6 o'clock start is damned to commence with. I consider it a relic of barbarism, and is, I believe, at the root of a great deal of bad timekeeping. In the man's most efficient stage covered by Sections 2 and 3 of the curve, there is only one break in a period of 7½ hours. This curve then shows that a one-break day, allowing the operator to start warm and well fed and to finish without exhaustion, is the correct system.

If we are to give practical effect to a lot of the loose talk that goes on about educating the operators, then the question of physical exhaustion due to early starting and long hours must be considered. You cannot get good mental results from a tired body. I have taken it out, and I find the average hours worked apart from overtime are not more than 49 per week, so that you are really working a very badly balanced 48-hour week, and by readjusting the distribution of that time on the one-break system you must, in my opinion, get more efficient working.

It is often remarked that men lose very little time when they are on night shift because they are paid more money. I do not agree with that reason. I believe that it is mostly due to the fact that a man's household have time to prepare a decent hot meal for him and get him away in good time for his night's work. I find that men work on the night shift not from a love of it, but because it enables them to average up their wages which are low on the day shift through the often intolerable conditions of our six o'clock start. The great majority of men who lose time on the day shift are not slackers.

We have seen that efficiency rises when the foreman gets going—we have seen that efficiency rises when the manager gets going—and from this we reflect that the highest efficiency will be obtained by making this working period common to all who have anything to do with the business, i.e., manager, clerks and operators should start at the same time.

Before I pass from this curve I would suggest that it would make a bit of useful education to any foreman or manager to plot out this curve of his own efficiency. If he has the usual amount of self-conceit prevalent in foundries, he will get his curve away up above the theoretical maximum line (as shown by line C in Fig. 2). Of course, as the manager or foreman is supposed to be on top of his job, his theoretical efficiency line will be above the operator's line, as shown by line B. Now, if he is an honest thinker he will quickly recognise that the super-height of his curve is the measure of his amount of swelled head, and when he examines the same period of time on the production curve he will most likely find a V-shaped depression as we have on the first curve at W—the rut that the moulder is in. This curve of swelled head is one of the contributory causes to the rut. Erode the peak, and the rut will begin to fill up. By efficiency I mean a high rate of production of good-quality castings, at a relatively low cost rate, from a body of well-paid, contented operators and staff.

I mentioned that we must always keep before us the factor of continuity of direction. How rarely

one finds this in a jobbing steel foundry. There is rarely any idea of a proper sequence of operations. The furnace is often in the wrong place, drying stoves in the wrong place, making it incumbent on the travelling cranes to be continually shifting moulds backwards and forwards. If the furnace is at one end of the shop and the drying stoves at the other, you close and set the moulds at the stove end, the steel has to travel over the moulding area to the pit, and the moulders for an hour, say, are left craneless. That interferes with output.

Let us look at the sequence of operations in the foundry:—Moulding, core-making, drying, closing, casting, knocking out, sand blasting, riser removal, annealing, fettling, testing, finishing, loading. I have left out pattern-making, for in jobbing-shops most of the patterns are sent in and the pattern-maker's chief business is to keep the moulder right (if he can) in his closing. With the exception of hand moulding, core making and melting, the whole business is purely mechanical, and the speed of production largely depends on the balance of output from each operation, the perfection of the means of transit from one operation to another, and the efficacy of the machinery for performing each operation.

What a misnomer the term moulding shop often is in the jobbing foundry. How often one finds it a conglomeration of moulding area, box park, knocking-out shop, fettling shop, scrap-heap, and goodness knows what. The moulding shop should be a place to mould in; the dirty work should be done in other shops fitted for the purpose. Then a bit more of the valleys in the first curve will be found filling up.

There is no secret in a steel foundry; there is plenty of delusion, and the whole question of "quantity" resolves itself into an engineering problem of the application of the straight line. It is, however, when we come to consider quality in a steel foundry that we are confronted with the real problem. Quality is that condition in a casting that enables it to pass through all the successive stages from the casting pit to the loading bank with a minimum of trouble and cost and strengthens the salesman's hand by making the buyer (like Oliver Twist) ask for more.

Quality depends primarily on two factors:—(1) The foreman moulder; (2) the molten steel. I put the steel last, because, in my experience, it is the least important of the two. The instructions given to the operating moulder by the foreman, such as the position to place the runner, the right way to mould the job, the position and size of risers, the use or abuse of core irons, and the putting on of brackets in 99 cases out of a 100 determine whether the job will be good or not, and it is in these points that the weak spot in our steel foundries lies. The great majority of foremen moulders are not properly trained.

It is a most melancholy reflection that such a fine body of men should be handicapped by what is a serious defect in our shop training. I mean the education of foremen to think on correct scientific lines, enabling them to rise above the "hit and miss" methods so prevalent in our shops. Employers of labour will have to face this question, and its solution starts with the apprentice moulder. A foreman must come from the operating moulders; he must go through the mill of the apprenticeship drudgery, but employers must insist that mental training proceeds with the manual training, and part of that mental training should, I think, be carried out in the works, so that lads can be taught to appreciate the co-ordination between manual effort and technical training, not as a thing apart from their daily toil, but as a powerful weapon to enable them to make that toil more productive in earning capacity for themselves, and for the man or corporation that employs them.

The excessive use of brackets, core irons and risers are, in my opinion, the distress signals of the foreman moulder. He is too often so obsessed by the fear of what the steel-maker is going to give him that his mind is incapable of analysing his difficulties correctly. It is always good policy for a manager when the foreman tells him that last night's charge was like "bull muck" to examine the charge sheet, and get busy in the fettling shop. He won't take long to find which casting has worried the foreman. You'll usually find it by the number of brackets on it—a kind of steel hedgehog. Tell a foreman a casting is a "ship casting," and he'll go bracket mad. Tell him it's a furnace door, and you'll get a better casting with no brackets on it at all. I firmly believe that the blaming of the steel-maker for bad or cracked castings is the greatest piece of bluff ever put up in a workshop. For many years now I have never failed to get correct test results from the steel supplied, except where it has been contaminated in the mould or spoilt by mechanical action in the mould. I do not think it reasonable to suggest that 30-ton steel, giving an elongation of 30 per cent. on 2 in. and 180 deg. bend (a steel being made daily in our Sheffield foundries) is a bad steel or a steel responsible for the cracks in castings.

Foreman moulders do not fully recognise or believe that the critical period of a steel casting is just at the point of change from the liquid to the solid state, not only because the metal is then in a pasty condition, but because the main contraction comes on that moment, and the casting will crack if the mould and cores are not sufficiently friable to allow that sudden movement to be unrestricted. This contraction is so fast that in a job cast vertically you will frequently find that part of the steel near the base of the riser has lagged behind the mass and appears as a row of small stalagmites on the cold casting. I have repeatedly found them 5-16-in. long on the top end of a cylinder whose contracting length was 4 ft.

Fig. 3 illustrates the point. A dome-ended cylinder was cast with the dome end up and the feeding riser placed as shown. The joint of the top box and the riser box are shown.

In cases where no fin formed at these joints the stalagmites of steel were much in evidence, but when fin did occur through bad jointing the stalagmites were absent, and the fins were bent almost vertical, and in one case, although the fin on the riser was only ¾ in. wide by 1-16 in. thick, a crack 9 in. long occurred on the riser just below the fin. Examples such as this show the speed of contraction, and the danger of cracking through even a very slight resistance to contraction at the critical point of solidification.

You can always tell whether a foreman grasps this question of contraction by watching if he slackens a job after it is cast. All slackening should be done when the mould and cores are being made and dried, and with the exception of easing round a riser the casting should not be disturbed until it is cold enough to lift, and I want to see foreman moulders so trained that, without

a thought to the steel, they can produce a sound steel casting by scientific moulding methods.

A great deal has been talked about the excellence of German steel castings. I have examined every German casting I could get hold of, and I have not found one made of better steel than we are daily supplied with in our Sheffield foundries, but I believe I am right in saying their methods of moulding were superior. I have seen a German 12-ton ship casting, and it had been made with only eight brackets on it. I have seen a similar British casting made of better steel with 200 brackets on it, and the German casting was the more saleable article—"it had quality." My experience forces me to the conclusion that method of manufacture in the moulding shop and not the steel is the main factor in securing quality in steel castings.

Discussion.

The PRESIDENT, in inviting discussion, said Mr. Watson's Paper was most instructive and challenging. He went with him a long way with regard to the 6 o'clock start. He certainly thought it was a barbarous arrangement, and hoped in the good days coming it would be altered. A representative of the Ministry of Munitions had been to Sheffield endeavouring to ascertain the causes of so much lost time, and inquired of a few of the offenders. He got no further than the reply: "Oh, you must ask the missus." (Laughter.)

MR. BROWN said he had listened with a great deal of interest to Mr. Watson's Paper, and there was nothing in it he could take exception to, although he did not think a steel moulder would make a cylinder such as Mr. Watson had illustrated on the blackboard, in the way he described, unless he expected trouble. With regard to the use of brackets, a certain number in their proper place would doubtless be an advantage, but hundreds were put on quite unnecessarily, and caused a lot of needless labour in the fettling shop. A mould properly prepared should be liberated without difficulty, although he had frequently seen them dug out. He was a believer in a reasonable number of brackets in the right places, but they should not be overdone.

MR. CROSBY said he had listened with very great pleasure to the Paper, and especially Mr. Watson's remarks about efficiency. He would like, however, if he dared, to ask what was his waster percentage? The bracket question was largely involved in that, and it should be considered in conjunction with that of waster percentage. He had had long experience in an eight-hour shop, and quite agreed that the time was coming when this would become universal. But was the day to be divided into three shifts, or was there to be a short day shift and a long night shift? Overtime had to come into consideration, and this was, of course, at a higher rate on the night shift. It was a question affecting not only Sheffield but the whole country. Another point for consideration in connection with an eight-hour day was whether it would apply to machine tools. Would any ordinary sane man contend that as much could be got out of them in eight hours as in twelve? He quite agreed with Mr. Brown on the question of brackets, and he believed Mr. Brown would agree with him that the bracket question had a considerable bearing on that of wasters. In his own foundry they worked with about 1¼ to 1½ per cent. wasterage on the year. Lay-out of the foundry was a very important factor in maintaining efficiency. The crane service should be considered above everything else.

MR. DARLEY thought the Trade Unions were greatly at fault for not classifying workmen according to ability. When he was admitted to membership it was merely a question whether he had served a certain apprenticeship. Whether or not he was a qualified tradesman never entered into the question at all. Employers would look at the Unions with a much more favourable eye if they could be sure that the Unions were helpful in getting the greatest efficiency from the men.

MR. WATSON, in reply to the points raised, said he certainly did not want it to be supposed that by the waving of a magic wand all brackets could be dispensed with; all he was condemning was the abuse of brackets. He quite recognised their use. In the case of the German casting to which he had referred there were eight brackets, but all these were on the line of natural contraction, and were necessary to hold the sections together. Many jobs were cracked because they had been run in from the wrong end or because too big a fillet was left on. In his own experience, he had found that the waster percentage went down as the number of brackets was reduced. In endeavouring to produce the very complicated valves required for Admiralty work without cracks there was at first a very high percentage of wasters, but he tried leaving off brackets and altering the methods of moulding and of running, and very much greater success was then obtained. Very often brackets put on to hold sections together simply acted as anchors, and would not let the casting move at all. Of course, in his curves he was dealing only with datal rates of working, and not with machine tools. That was entirely a different question, and he fully recognised the difficulties of the night-shift problem, and it would have to be dealt with in the matter of supervision on lines entirely different to those of the past. Night-shift work at present was the most inefficient, because while all the heads were at the works during the day, the night work was left to the superintendence of an under foreman. He quite agreed that the Unions would have to take up the question of the classification of workmen.

The PRESIDENT felt there was great need and scope for the young moulder to get a better understanding of the scientific side of his job. There was no branch of industry where this matter was more neglected. A moulder's apprentice who had taken a technical-school course was a curiosity, and he was very pleased to learn that the Council of the Foundrymen's Association had in hand a scheme for the encouragement of a better class of youths to enter the moulding trade and were to make provision for developing their ability. There was no doubt that some form of continuation schools where apprentices could carry on the study of the theoretical side of their work would become compulsory. A learner in any trade should certainly know what he was aiming for and the reason he was doing any particular piece of work. Under the present haphazard scheme a lad might idle all his time away in the shop, where it was no one's business to tell him anything about the work.

COUNCILLOR T. H. FIRTH, in moving a vote of thanks to Mr. Watson, said he had been particularly impressed by the remarks in regard to the early morning start, and was convinced there was a great deal in his contentions. Experience in his own moulding and machine shops confirmed the truth of this. With regard to the attitude of

Trade Unions, there was no doubt that masters and men in this country would have to work on different lines in the future. In his opinion, one of the things the war would teach them was that it was the duty of the Government to guarantee to every able-bodied man continuity of employment at wages adequate to keep a man and his family respectable and comfortable. But after he got that minimum wage every man should be "on his own," and the best man should have the freedom and opportunity to come to the top. To-day he had moulders who were not worth half the money they were getting, while they were working by the side of men who were worth double what they were getting. But the Union said they must all be paid alike. The Government should say that every man should be paid a living wage, but after that any man should be able to earn what he could. He believed it would be only by some such system of universal piece-work that German competition could be met. There was no reason why men should be thrown out of employment during a slack period. There was plenty of work in the world for every man, and the time was coming when Governments would have to guarantee continuity of employment.

British Foundrymen's Association.

We publish herewith a portrait of Mr. J. Little, of Sheffield, who was unanimously elected Junior Vice-President of the British Foundrymen's Associa-

tion at the annual meeting this summer. Mr. Little is well known among the members, particularly in the Sheffield Branch, of which he is now President.

A FIRE broke out at the works of Mr. H. H. Ellaway, brass founder, Granville Street, Broad Street, Birmingham, considerable damage being done.

United Kingdom Furnace Statistics for 1916.

We reproduce the subjoined figures from the Statistical Report recently issued by the Iron, Steel and Allied Trades Federation.

Converters and O.H. Furnaces in 1916.

The following table indicates the average number of converters and open-hearth furnaces at work and idle in 1916:—

	Active.	Idle.	Total.
Converters—			
Acid	57	23	80
Basic	15	9	24
O.H. Furnaces—			
Acid	349½	82½	432
Basic	153	26	179

Electric Furnaces in 1916.

The total number of electric furnaces built or building in 1916 was 91, as against 45 in 1915. The following table shows the numbers according to types and output as far as information was available:—

	Number.	Total capacity in tons.
Héroult	32	153½
Electro-Metals	22	60½
Greavee-Etchell	20	*
Rennerfelt	5	8.2
Snyder	4	1½
Stassano	3	*
Stobie	2	*
Frick (since converted)	1	*
Special design	2	*

* Not given.

REFRACTORIES FOR STEEL FURNACES. — In discussing the Paper on this subject by Mr. W. J. Brooke, of the Shelton Iron, Steel, and Coal Company, read before the Refractory Materials Section of the Ceramic Society, Mr. W. J. Jones, of the Ministry of Munitions (Refractory Materials Department), pointed out that the shortcomings of those engaged in manufacturing refractory goods, should not be put down entirely to culpable indifference or negligence. Since the war commenced the demand for silica bricks had increased very considerably. Moreover, many of the men who were getting ganister had joined up, and their successors could not expect to show the same results as those with experience. Bricks might be the same in chemical analysis, but not in physical properties. Material containing 98 per cent. silica was not suitable for making bricks, and no practical silica brick-maker would think of using such material. As regards the jointing, 15 per cent. seemed a great amount. Before the war a few magnesite bricks were obtained from Norway, and these were fairly high in silica. Probably the loss of half the weight in calcining was the cause of no serious attempt being made to produce magnesite bricks for so long a period. He cordially agreed with Mr. Brooke's suggestion regarding close intercourse between makers, users, and scientists. The effort should be national and concerted, say, with one co-ordinating centre presided over by Dr. Mellor, and a number of other centres, such as Sheffield, Glasgow, South Wales, Birmingham, etc., each dealing with different questions. The suggestions respecting co-ordination of effort were also supported by several other speakers.

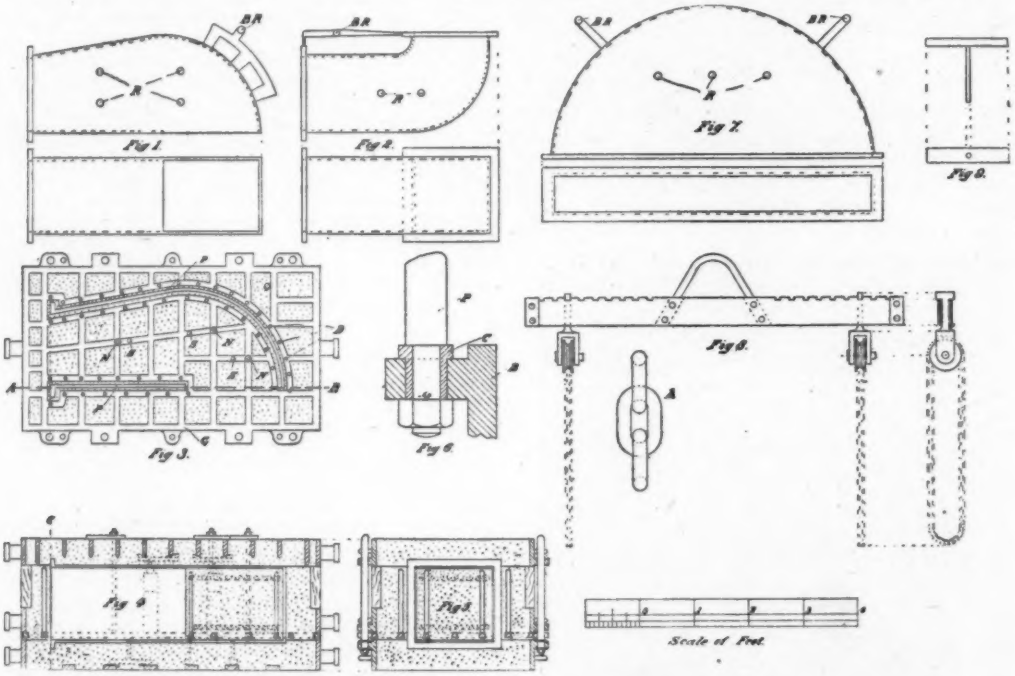
Emergency Jobs.

By F. Andrew.

The following article describes the moulding of two square pipes and a half-circular wheel guard. The methods adopted were unusual, but rendered necessary for several reasons, chief of which was the urgency of the jobs and the necessity for economy. Full patterns and coreboxes were out of the question in the time available, and as only one each was wanted off, the expense of such patterns was prohibitive. The resultant castings fully justified the writer's departure from usual methods, and full advantage will be taken of the methods in future jobs of a similar character.

The Patterns.

These consisted in each case (Figs. 1, 2, and 7) of two boards of the shape and size of the cores



in plan, as shown in the upper views by dotted lines. The sides of the patterns consisted of boards, a length equal to the height of the patterns, and varying in width from 4 in. to 2 in., equal in thickness to the required thickness of the casting. These were set around the bottom board, and fixed temporarily by two screws in each piece, while at the upper end each piece was lightly fixed to its neighbour by a small sprig. The sides completed, the top board was placed in, and was supported by battens on the upper side, which projected about half an inch, and rested on the sides. This completed the pattern-making, and, with the exception of the battens on the top and bottom boards, the patterns were just models of the castings to be made from them; no core prints and therefore no coreboxes being required.

The Moulds.

In each of the three cases the method of moulding was essentially the same, so that it will be sufficient if the moulding of the pipe shown in Fig. 1 is described. A suitable box was found consisting of top part, a shallow mid-part, and a drag or bottom part. The mid-part was made up to the required depth by a wood frame 2 in. in thickness. The drag was set level with a bed prepared, on which to lay the pattern, ¼ in. below the box joint. To carry the sand in the mid-part, forming the sides of the mould and the core, a grid was cast with openings to allow of its being bedded on the bottom board and the joint, after temporary removal of the top board of the pattern, the sides of which passed through these openings.

Fig. 3 shows this grid, claywashed and bedded on a layer of sand ready to receive the mid-part which rests on it, the two being fixed together by the four rectangular snugs, two on each side of the grid, and the lifting handles of the box which come immediately above them. In Fig. 3 the following letters indicate the different parts and their positions:—P, sides of pattern; G, grid; D, prods all round the sides of the pattern, to which they are equal in height, approximately; S, cast-iron-stems cast in the grid and passing through the bottom board of the pattern and coming level with its lower face; N, ¾-in. nuts for lifting screws.

The grid and mid-part being secured, the lifting screws are set in the nuts, the bow at the upper end being about an inch below the top of the

pattern, and three bricks placed on the grid on end in the places where the core is to be studded down. Ramming can now proceed with for a depth of about 4 in., the top board of the pattern being replaced while the outside is rammed, and taken out while the core is being rammed. At this stage the core is vented and the vents covered with a thin layer of ashes and carried to outlets at the side and end of the box, formed by ramming up a wooden peg.

Ramming is now continued until about four inches from the top, first outside and then inside as at first, to prevent the pattern being rammed out of shape, and the necessary studs placed on the tops of the three bricks previously referred to, and set level with the upper face of the core. Another layer of ashes is laid and connected to the vent pegs and ramming again continued to the top. A bed is strickled for the top board of the pattern and vented to the upper layer of ashes. The top board is tried in and the position of the holding-down studs and lifting screws marked on it. Holes about 1 in. in diameter are made where the studs come, and others about 3 in. square where the lifting screws come; and the board is then replaced and the top joint made ready to receive the top box. This is now lowered on, and hook bolts passed through the square holes in the top of the pattern to the bows of the lifting screws and secured by means of a plate and nut to the top box.

The studs for holding down the core (see Fig. 9) are cast open-sand, being simply a flat bar with a prod ¼ in. in diameter cast in the centre. This prod is cut to length, so that it passes through the holes in the top of the pattern and beds on the studs in the core, the crossbar being wedged to the bars of the top box.

Runner and riser pegs are put in position and the top rammed up, and the whole is then ready for turning over. This is quickly and neatly done by the beam and roller slings shown in Fig. 8, the three parts, without being bolted together, being lifted by the chains, each of which passes round the three trunnions on the ends of the box parts, any movement at the joints being prevented by the guide pins which fit the three boxes together. The bottom part is lifted off and knocked out, and the screws fixing the sides of the pattern to the bottom board of the pattern are taken out, and the joint made good. The bottom box is replaced and three more studs, as Fig. 9, are fixed between the studs coming through the face of the pattern and the bottom part bars, the bottom part being then rammed up.

The whole is again turned over and bedded solid. The top and mid-parts are secured by bolts and lifted off the bottom box (which is a flat surface, and can soon be finished) and again turned over and set down. The bottom board can now be removed, and the sides of the pattern, consisting of narrow pieces, drawn out by means of a pair of pincers, if necessary, which presents no great difficulty. The moulder can now finish this face, which is wet blacked for skin-drying on account of the nearness of the grid, and the whole again turned over on to the bottom box. The hook bolts fixed in the lifting screws are loosened and the nuts taken off to prepare for lifting the top off.

This done, the top board is removed and the mould finished, and as the bottom face of the mid-parts requires drying, bars are placed across the box and the lifting screws again secured to these by hook bolts to prevent the core sinking when it is removed and lifted off the supporting studs. A couple of bucket fires placed underneath suffice to do the drying, and by the time this is done the top is finished, the bottom gates are cut, and the whole is ready for closing.

After the mid-part has been replaced, the crossbars and hook bolts are removed, the holes over the lifting screws are made up, and the top box can then be replaced. There are no chaplets to secure and the core cannot shift, so the mould can be bolted together and got ready for casting. Fig. 4 shows a view in elevation and section (along A B, Fig. 3) of the mould containing the pattern and before parting. Fig. 5 is a sectional elevation of the completed mould on C D, Fig. 4. In this example the four runners R (see Fig. 1) are enclosed in one runner box, the bottom runner B R, Fig. 1, being in a separate runner box. When pouring, about 2 cwt. is poured in at the bottom runner, and as this is just draining the other runner box is filled from a ladle and casting completed.

In Figs. 2 and 7 pouring was carried out in a similar manner, except that in Fig. 7 there were three runner basins, two for filling the bottom and one on the top to complete the casting. In each case convenient boxes were available, consisting of top part, mid-part, and drag, but in the absence of these the method could still be carried out without any difficulty, using simply a top part. The grid would then require to be made stronger around the outside and provided with trunnions and flat prods about 3 in. by 1 in., and the full depth of the pattern along the sides and ends of the grid. By placing boards on the inside of these prods the equivalent of a mid-part would be obtained, and the bottom of the mould could be made in the foundry floor.

In Fig. 6 is shown a section of one of the lugs for carrying the guide pins. It is customary to make the holes in these to the same size as the lower end of the guide pins. For convenience, when using several mid-parts with a job requiring long pins and ramming up on a top part, these holes may be made the full size of the body of the pin at P, so that the drag containing them can be set immediately over the parts beneath it. To secure the pin in the lug cast on the box side B, a sleeve with a shoulder as shown at C, or a plain sleeve and a washer, forms a support for the pin, while the nut is screwed up tight.

The grids in each of the castings shown in Figs. 1, 2, and 7 were removed or loosened as soon after casting as practicable, a much simpler job than if a dry-sand core had been used. It will be seen that it was impossible to get the cores out of centre, and each of the outlets had a clean face, without fin, which would be impossible to obtain by ordinary methods using a separate core made out of a core-box. All dimensions can be obtained by reference to the scale shown, except Fig. 9, which is an enlarged view of the studs for securing the cores, and A, Fig. 8, where the type of link of which the roller chains are formed is shown.

STEAM JET FOR CONVEYING FURNACE ASHES.—One of the most recent methods of conveying ashes in America is by means of a steam jet through conveyor pipes made of a special hard cast-iron mixture to resist the abrasive action of the ashes passing through the pipes at high velocity. The elbows and special fittings are so designed that parts wearing out rapidly can easily be replaced. The design of the ejectors is stated to provide for an economic consumption of steam.

Some Geological Characters of Moulding-Sands

By Professor P. G. H. Boswell, A.R.C.S., D.Sc., F.G.S.*

How the Geologist may be of Use.—It has become a matter of urgent national necessity that we should investigate and know thoroughly our home resources of moulding-sands, particularly those essential to the steel industry. Geologists have been consulted—to a much greater extent since the outbreak of war than previously—and asked to advise upon fresh supplies of moulding sands. These are required to supplement or replace those hitherto used, many of which were imported from that part of the Continent now the seat of war. The difficulties of transport, due to shortage of ships and labour, have made it the more desirable that we should know how far we can be self-supporting in this matter, since it concerns acutely what is perhaps our greatest industry. Geologists, particularly those interested in sands, endeavoured to put their knowledge of our British resources of likely deposits at the service of the manufacturers, but were met at the outset by a serious difficulty. The geological characters of such sands, and the stratigraphical conditions under which they were found " in the field," were to all intents and purposes unknown. The exact chemical and physical properties of certain highly desirable moulding-sands were matters of keen dispute among the experts. The literature upon moulding-sands was voluminous, but also contradictory in the extreme. Despite the fact that geology can doubtless be as controversial a subject as any, it found as a rule no place in the arguments. Yet the questions of the occurrence and properties of moulding-sand, which to the geologist is as much a rock as granite, are essentially geological matters. The peculiar mode of occurrence and association of such sands, the minerals present and their decomposition products, the sizes of the constituent particles and proportions of the " grades " are matters upon which the geologist can speak *ex cathedra*. Only by the investigation of moulding-sands along certain definite geological lines can we acquire the information which will enable us to search for or predict further supplies.

This must not be taken as implying that the geological study of moulding-sands is likely to prove a panacea for the multitudinous troubles of the metal-founder. The chemist and physicist take up the work where the geologist is compelled to leave it, and the reciprocity is emphasised when the geologist resumes his search fortified with the knowledge born of the experiments of his scientific brethren. The practical testing of the sands may be shadowed in the laboratory, but it is satisfactorily and finally conducted only in the works, and there alone under the most exhaustive standard conditions. The metallurgical and physical testing of moulding-sands is an extremely important matter, but, like the native wit of the moulder, who is usually so excellent a judge of the value of his sand, it must be exercised on materials already found—it does not tell us where to go to find them.

Most of the literature on moulding-sands is concerned with the chemical analysis, screening, testing of fire-stability, and investigation of the physical properties of the materials. It may, therefore, be of interest to consider some of the geological characters of moulding-sands, particularly those deposits used for " green-sand " as well as " dry-sand " moulding in the steel industry.

The obvious method of extending our geological knowledge of these materials is to investigate the characters of the sands, which have been proved in the foundry to be of outstanding merit. If, in the course of such an inquiry, we find that certain properties are peculiar to these sands and are not possessed by materials which are found to be unsuitable by actual trial, we shall have moved a step forward. If, further, we discover that the peculiar properties are common to all moulding-sands whether they are used for the casting of brass, bronze, iron or steel, but that they are shown to the most marked extent by the comparatimely few sands suitable for steel-moulding (where the conditions are the most exacting), we may fairly claim that the agreement is raised above the level of mere coincidence. It is then reasonable to suppose that the peculiar properties manifested are essential ones, having regard to the economic purpose, and that other deposits bearing similar properties may be tried in the works with some measure of success.

Analysis of Sands.

Mechanical or Grade-Analysis.—In this paper it will perhaps be as well to confine our attention to one fruitful and distinct line of work upon moulding-sands, namely, that dealing with mechanical analyses.

The " texture " of moulding-sands has frequently been dealt with, and its importance has never been underestimated. But it is questionable whether the geological significance of the texture has ever been properly realised. Yet the texture of the raw sand is essentlaliy a geological matter, and is indissolubly linked with the questions of deposition, mode of occurrence, and " weathering " of the deposit.

Analyses of sands may be of three different kinds; all may be carried out satisfactorily in the chemical and research laboratories of the works. Chemical analysis is familiar to everybody. Mineral analysis is a more esoteric inquiry, usually indulged in by geologists only, but nevertheless of considerable bearing on industrial questions. Mechanical analysis has been carried out by the water-engineer, the ore-dresser, the potter, and the cement-manufacturer, among others, with the idea of finding the size of the constituent grains in a sand, and the proportion by weight of grains lying within a series of size-limits agreed upon. The following size-limits or " grades " form a suitable series :—

Greater than 2 mm. diameter ..	Gravel grade	
Greater than 1 mm. and less than 2 mm.	Very coarse sand	Sand Grade
Greater than 0.5 mm. and less than 1 mm.	Coarse sand	Sand Grade
Greater than 0.25 mm. and less than 0.5 mm.	Medium sand	Sand Grade
Greater than 0.1 mm. and less than 0.25 mm.	Fine sand	Sand Grade
Greater than 0.05 mm. and less than 0.1 mm.	Superfine sand or coarse silt	Silt Grade
Greater than 0.01 mm. and less than 0.05 mm.	Silt	Silt Grade
Less than 0.01	Clay grade	

* mperial College of Science and Technology, London.

Method of Work.—The coarser grades may be separated by means of sieves, but the finer ones can be accurately divided off from one another only by flotation in a fluid, water being generally used. Formerly, settlement was adopted through columns of still water of different heights, and for varying lengths of time. The finest particles, of course, take longest to subside. This method is not susceptible to exact treatment, so the reverse process, known as *elutriation*, is the one usually employed. Upward currents of water are so adjusted as to carry off grains of definite size. Only a very slow current travelling, for example, at 0.12 mm. per second is required to wash off particles of the mud-grade, 0.01 mm. or less in diameter.* Several forms of apparatus have been used, but the simplest is illustrated in Fig. 1. It consists of a cylinder "A" of known area of cross-section, equipped with a manometer-tube "B" and an overflow tube fitted with a jet "C." Water enters at the lower end of the cylinder from

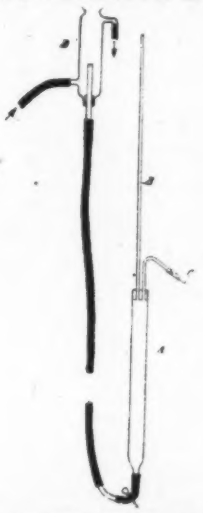


FIG. 1.—A SINGLE VESSEL FORM OF ELUTRIATOR.

a reservoir "D," which can be moved vertically up and down so as to vary the head. The required velocity is obtained by adjusting the size of the jet-opening "C" and the head of water in "D," and is marked by the water-level in the manometer tube "B." By having a number of detachable jets of different apertures and by altering the head, it is possible to separate a number of grades, beginning with the smallest. Different cylinders of varying areas of cross-sections may similarly be used for different grades. A weighed amount of sediment is placed in the cylinder. In each case the elutriation is allowed to go on until the upper part of the cylinder shows clear water. The sediment which has been carried over in successive crops is collected, dried and weighed.

The velocities at ordinary temperatures corresponding to suitable grade-sizes are as follows:—

0.4 mm.	diameter	..	44	mm. per second
0.3 "	"	..	36	" "
0.25 "	"	..	30	" "
0.2 "	"	..	25	" "
0 1 "	"	..	6 7	" "
0 05 "	"	..	1.78	" "
0.01 "	"	..	0.12	" "

* For a detailed account of the process, and references, see: "British Resources of Sands Suitable for Glass-making, with Notes on Certain Crushed Rocks and Refractory Materials." Pub. at the Instruction of the Ministry of Munitions, by the Imperial College of Science Longmans, Green & Co. 1s. 6d.

The methods frequently adopted of washing off the clayey material, and then sifting or "screening" the residue, are not sufficiently exact for scientific work. There is a lower limit of screening, beyond which it is not effective. Small-holed sieves have a square mesh and are liable to rust. They are frequently of inaccurate dimensions. Little or no standardisation of aperture exists (other than the I.M.M. screens) and the mesh is frequently not to specification. It is desirable, too, that grade-sizes should be expressed in terms of metric system units.

Before a sample of moulding-sand is elutriated, it should be treated in such a way as to ensure that the clay particles will free themselves from the coarser sand grains and from one another. If the clay aggregates are not broken up, they will act as coarser grains, and the analysis will be vitiated. The weighed sample must therefore be "deflocculated" before being subjected to elutriation. Boiling with water for about five minutes is frequently sufficient, but if much clayey matter is present, or the clay is fairly plastic, a slight trace of such substances as ammonia, sodium carbonate, or pyrogallol, must be added to promote deflocculation. In this connection it is interesting to note that all good moulding-sands require very little or no deflocculation. The constituent particles break away in a very characteristic manner when the sand is dropped into water, a phenomenon mostly resembling that observed when the clay known as "fullers' earth" falls to powder if similarly treated. Plastic clays, especially those which have become "leathery" as a result of pressure and movement, are the most difficult to deal with; this suggests that the clay-grade in moulding-sands is not highly plastic, or that plastic clay is not present in great amount.

The drying of clays and clayey sands also tends to flocculate the particles and increase the difficulty in elutriation. All good moulding-sands possess the property of holding mechanically a considerable quantity of water. As it is frequently desirable not to dry the sample before elutriation, but to run an analysis on the material as collected in the field, the water-content, up to the temperature of the drying of the separated grades, must be estimated separately. The grading analysis may then be recalculated to 100 per cent.

Graphical Expression of Results.—The graphical expression of the figures obtained by such methods of mechanical analysis is an important matter. H. Ries, in a paper on moulding-sands in the "Transactions" of the American Foundrymen's Association, 1906 (p. 63), uses the kind of diagrams known from their shape as "butterfly" diagrams. A similar, but rather better, mode of expression has been long employed for igneous rocks such as granite, basalt, etc. After using many forms of graphical expression, the writer decided to adhere to that involving the use of curves. Similar curves have been used for expressing the grading of filtration-sands in the United States,* and of the moulding-sands in Denmark.†

The method here adopted is as follows (Figs. 2 and 3):—The limits of grade-size are marked off horizontally as abscissæ (proportionately to the logarithms of the diameters of the particles), and the "cumulative percentage weights" of the grades vertically as ordinates. An example will best ex-

* Water Supply and Irrigation Papers, U.S.G.S., No. 62 (1902) Slichter, "Motions of Underground Waters."

† Dan. Geol. Underæg. ser. 2, No. 14: Poul Harder. "Undersøgelser over Nogle danske Sandsorters Anvendelighed til Formsand i Jernstoberier."

plain this. The mechanical analysis of a specimen of one of the best sands for green-sand steel-moulding, from St. Erth, Cornwall ("Cornish red"), is as follows (see Fig. 3):—

> 1 mm. diameter, nil; > 0.5 and < 1 mm., 0.6 per cent.; > 0.25 and < 0.5, 37.3 per cent.; > 0.1 and < 0.25, 42.7 per cent.; > 0.01 and < 0.1, 5.7 per cent.; < 0.01 mm., 13.7 per cent.; total sand-grade, > 0.1 mm., 80.6 per cent. (All percentages recalculated to 100, after removal of water at 100 deg. C.—which amounted to a loss of 11.6 per cent.)

The cumulative percentages marked off respectively as ordinates at the diameters 0.5, 0.25, 0.1, 0.01 mm., are 0.6 per cent., 0.6+37.3=37.9 per cent., 37.9+42.7=80.6 per cent., 80.6+5.7=86.3 per cent; that is, in each case, the total percentage weight of the sediment of diameter *greater* than each grade-size is plotted.

Considering first some ideal sediments, we see that, in Fig. 2, a perfect sand consisting of 100 per cent. of the grains of the diameter 0.25 mm., would be represented by CD, a perfect silt by such a line as EF, and a perfect clay by, say, GH. A perfect gravel or very coarse sand might similarly be represented by AB. Ideal deposits like these do not appear to occur in nature. Many natural deposits are nevertheless well-graded, and when their mechanical analyses are plotted, yield smooth and simple-shaped curves. A true loam, for example, containing about one-third sand-grade, one-third silt, and one-third clay, is represented by a curve which is almost a straight line (WX in Fig. 2). An actual well-graded sand is indicated by TU, and a clay by YZ.

Moulding-sands do not altogether belong to the "well-graded" class. It is not easy to imagine the exact condition of deposit which caused the throwing down together of coarse sand and fine clay. Certainly, if river or sea-water had an opportunity of washing the constituents freely, they would be sorted out and separated. Some portion of the clay may, of course, have resulted from the decomposition of certain minerals *in situ*, and so have been formed after the deposition of the bed.

Mechanical analyses carried out by the writer in the laboratories of the Imperial College of Science and Technology on some well-known moulding-sands used in Britain are as follows:—

For the better realisation of the significance of these figures, the analyses are graphically plotted in Figures 3 and 4. The former diagram (Fig. 3) deals with those moulding-sands which are highly appreciated for the casting of iron, brass, and

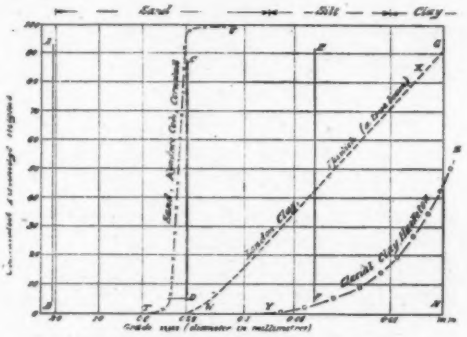


FIG. 2.—MECHANICAL ANALYSES OF SEDIMENTS—GRAPHICAL REPRESENTATION.

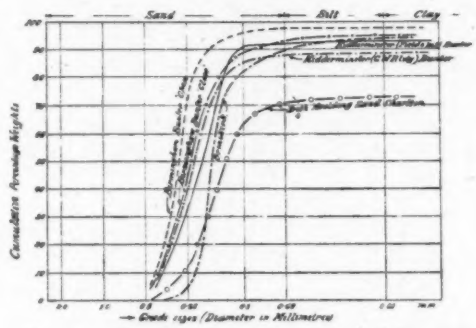


FIG. 3.—MECHANICAL ANALYSES OF MOULDING SANDS (*a*) IRON CASTING, ETC.

bronze, where the temperature rarely passes beyond 1,250 deg. C. On the other hand, the sands of which the analyses are represented in Fig. 4, are those greatly esteemed in steel-casting, where much higher temperatures are reached, the contraction

	Coarse sand. > 0.5 mm.	Medium sand. > 0.25 and < 0.5.	Fine sand. > 0.1 and < 0.25.	Silt grade. > 0.05 and < 0.1.	Silt grade. > 0.01 and < 0.05.	Clay grade. < 0.01 mm.	Sand grade. > 0.1 mm.	Water driven off at 100° C. from field samples.
A.								
"Erith" sand Charlton (strong)	0.3	11.2	50.3	9.6		28.6	61.8	10.2
Kidderminster Sand, G.W.R. Quarry ..	—	33.5	51.8	7.8	4.0	2.9	85.3	4.9
Kidderminster Sand, Fields Quarry ..	—	32.4	59.0	0.9	0.8	6.9	91.4	8.0
Birmingham (Hockley) Open Sand	0.2	67.1	28.0	1.6		3.1	95.3	0.8
Ditto Close Sand	1.8	40.6	46.0	6.5		5.1	88.4	0.5
Wolverhampton Sand (Compton, J. Boot) ..	—	6.6	78.1	8.1	1.9	5.3	84.7	9.4
Ormskirk Sand	Tr.	4.3	77.8	12.6		5.3	82.1	—
B.								
Huttons Ambo Sand	0.4	16.1	72.0	0.25	0.25	11.0	88.5	1.1
Leighton Buzzard Moulding-Sand	1.5	6.7	75.8	3.3		12.7	84.0	2.0
"Cornish Red" Sand, St. Erth	0.6	37.3	42.7	5.7		13.7	80.6	11.6
"French Red" Sand	0.6	19.0	66.2	3.3		10.9	85.8	5.3
Belgian Sand	7.5	64.9	12.0	3.3		12.3	84.4	6.6
South African Sand	0.5	3.4	70.5	1.0	6.3	18.3	74.4	—

[A selection only is here given from a large number of results.]

of the casting is greater, and the conditions generally are infinitely more exacting.

What information as to the composition of the geological material do these tables and diagrams yield?

From the point of view of mechanical analyses, we may divide these moulding-sands up into two groups, placing in the first all the well-known "red" moulding-sands, such as those from Birmingham, Wolverhampton, Kidderminster, Mansfield, Worksop, Hensall, etc., all obtained from the

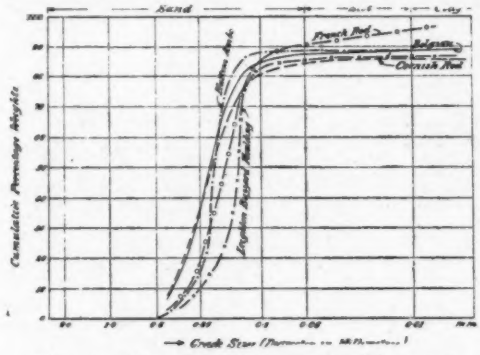


FIG. 4.—MECHANICAL ANALYSES OF MOULDING SANDS (*b*) STEEL CASTING.

formation known to geologists as the Bunter; and in the second group the remaining deposits. The first group of sands and certain members of the second group, such as the famous "Erith" sand, serve excellently for the casting of iron, brass, etc., but are not sufficiently refractory to be used for steel-casting. In this question of refractoriness, however, chemical as well as physical constitution is an important consideration. For the present, attention may be confined to the grading.

The Geological Significance of Mechanical Composition.

All the members of the second group of sands will be seen to contain a high percentage (over 80 per cent.) of the sand-grade (diameter > 0.1 mm.), a very low percentage of the clay or mud-grade (10 to 13 per cent.). This is a significant grouping of the sizes, and characterises all the best moulding-sands. But it is not a normal geological feature. Under ordinary conditions of sedimentation—in rivers, lakes, or on the sea-bottom—it is not usual to find coarse and fine material intimately mixed, with silt of intermediate size absent. The action of wind and water in Nature is to sort materials more or less definitely. The current which is able to transport fine mud as a cloud of suspended matter, is unable to move sand, and the stream which rushes down from the hill-country laden with sand and milky with suspended clay, is not likely to drop all its burden at once. Rather does it first drop the sand when its velocity is checked on entering quieter water, and carry on the mud to a more distant resting-place. Natural deposits are winnowed by wind and washed by water, and a strong tendency always exists for the simplification, i.e., the perfection of grading.

It is for this reason that good moulding-sands for high-temperature steel work are neither abundant nor widely distributed. The British Isles have not been thoroughly explored, as they certainly should be, in order to ascertain what resources of these sands are existent, but it is clear that only exceptionally during British geological history did the conditions obtain which yielded the material desired. In most natural deposits containing clay and sand, we find that silt is present, linking the two grades and intermediate in quantity. We may have little sand, more silt, and most clay, or much sand, less silt, and still less clay. The graphs representing mechanical analyses of such deposits, are liable to become almost straight lines (see the true 'loam" in Fig. 2).

Importance of Grading in Foundry Practice.

The mechanical analysis of a good moulding-sand may be interpreted in the light of its behaviour in the foundry. The sand-grade, which should consist as far as possible of coarse or medium sand, with little or no fine sand, renders the mould open and permeable to water, vapours, and gases. The presence of blistering and blow-holes in the casting is thus minimised. Superfine sand (below 0.1 mm. diameter) and silt, if present, tend to pack up the pore-space in the sand, and prevent this openness. The fine sand and silt also frit at a lower temperature and are thus less refractory than the coarser sand. The clay-grade is present as a "bond" to the sand, which is too coarse to hold together by itself. If too much clay is present, i.e., the sand is too 'strong," close-packing, with its attendant evils of blow-holes, etc., results. Very strong moulding-sands are therefore let down by the addition of a coarse and usually well-graded refractory sand (e.g., Leighton Buzzard sand, Lynn sand, etc.). The clayey material must be highly refractory to high temperatures, and as far as possible be distributed around each sand-grain as a thin skin. Hence the need for thorough and careful mixing of moulding-sands. Everyone knows how difficult it is to devise and obtain a machine which will mix intimately substances of such different grades as clay and sand. Gravity is continually working against the mixing, and endeavours to grade the mixture by bringing the coarser material downwards. If, therefore, deposits can be found occurring in Nature where this intimate mixing has been effected, and each quartz grain in a sand carries its own pellicle of clay, half the battle is over.

The Importance of Water-Binding.

Clay appears to owe its binding-power to its capacity for taking up water. Most clays then become plastic and impervious. When clay is utilised to line the bottom of ponds, it is well puddled with water. Too much plasticity is clearly undesirable in a moulding-sand, and one of the characteristics of a good sand is the way the clay separates freely from the sand when washed with water. It would appear to be the thin film of water taken up by the clay which constitutes the bind. When two clean plates of glass, such as those used for photographic plates, are joined by a film of water, we know how difficult they are to detach owing to the "surface tension" as it is called. Water standing in a cylindrical vessel is seen to creep up the sides of the glass at its upper surface, yielding the concave surface shape known as the meniscus. Mercury, on the other hand, gives a surface convex to the fluid. This may be simply explained by saying that the molecules of water in the surface-layer have a greater attraction for the glass than for one another, so tend to creep up the

sides. With mercury, the reverse is the case. On adding to the water a very small amount of such a substance as pyrogallol (pyrogallic acid of commerce—the photographic material), the "surface-tension," whatever that term may mean, is still further reduced, and the solution climbs to a greater height up the sides of the vessel. It may be for this reason that pyrogallol has been found to be of value for deflocculating clays or clayey sands before they are elutriated. We seek to ensure that the very fine clay particles are all separated from one another, and that no "flocks" occur. The reduced surface-tension of the water may help to attain this end, but doubtless other effects also are yielded by the use of the alkaloid. In this connection the good binding and, at the same time, retention of resiliency in a first-class macadamised road have been ascribed by my friend Prof. W. G. Fearnsides, F.G.S., of the University of Sheffield, among others, to the films of water uniting the lumps of road-metal.

Such an interpretation of the value of the grade-analysis, and the part played by water in binding the grains together, explains the reason for the excellence of the red Bunter sands so largely used in the British iron and brass industry. The mechanical analyses of some of these well-known sands are given in the tables and illustrated in Fig. 3. Their excellent binding properties are well-known and yet the clay-grade is seen to be distinctly low in amount. In spite of carrying so little clay, their water-holding capacity is large. When collected in the field, they may contain 8 to 10 per cent. of water (driven off at 100 deg. C.) without being really wet. This high water-carrying capacity is characteristic of all good moulding-sands, and the best, especially those with a high clay-grade, sometimes carry over 10 per cent. with ease. The reddish to red-brown colour of all the sands of this type (e.g., Belfast, Runcorn, Ormskirk, Hempshill, etc., as well as those mentioned before) is noteworthy and peculiar. The colour is one not common in British rocks, and is shown by those laid down under terrestrial, often desert, conditions.

Most British rocks have been formed beneath the sea, or under conditions where reducing and not oxidising action is the rule. The presence of plant and animal remains assists this reducing action very much, and sands and sandstones, as well as clays, tend to be whitish, blue, green, or grey, in depth, owing to the iron-compounds in them being in the ferrous state. At the surface they "weather" yellow, brown, or red, owing to the formation of the ferric oxide and hydrate by the oxidising action of the atmosphere. The scarcity or absence of living creatures and plants under desert conditions is said to result in the production of the oxidised and characteristically-coloured compounds of iron which stain the rocks, and the excessive evaporation doubtless tends to the production of the sesquioxide of iron, Fe_2O_3, instead of the hydrated oxides, $Fe_2O_3\ nH_2O$, so common in weathered rocks. The red colour of the Bunter sands is that of the mineral hematite (Fe_2O_3), which is much less soluble in acid than limonite. A sand stained by the latter may be cleaned very quickly by warming with dilute hydrochloric acid, but the red-coloured pellicle of the former is only reduced and rarely eliminated by continued boiling with strong acid. The skin of hematite round the grains of the Bunter sands has a remarkable power of retaining water by surface-tension.

Conclusion.

In the foregoing notes, nothing more has been attempted than to show the importance of the mechanical composition of moulding-sands and its geological meaning. A plea has also been entered for a more exact determination of such analyses and a suitable method of expression. The time has gone past scientifically where the crude results of screening can be considered sufficient. So far as chemical analyses are concerned, the fact that in a moulding-sand we have a mixture of grades clouds the issue. The food-value, flavour, and colour, of a plum-pudding rest upon the individual and separate properties of its constituents. A bulk chemical analysis of the whole pudding would yield as little information about each of them, and would certainly not tell us what were desirable and what undesirable ingredients. Yet for years we have been carrying out bulk chemical analyses of moulding-sands and endeavouring, usually unsuccessfully, to interpret the results. The information which would really be of great value would be the chemical composition, in all of the most successful moulding-sands, of each of the grades present. The exact composition of the clayey "bond" in each sand, the state of the combination of the iron and alumina, and the proportion of free and combined silica, and its state, colloidal or otherwise, are points of considerable interest. The mineral composition and evidences of decomposition-products in each grade, provide interesting matters for investigation.

It is improbable that moulding-sands with a natural bond will be other than in keen demand for the casting of iron, brass, etc., but there does appear to be a strong tendency developing in steel-casting towards the use of high silica-bearing, fairly coarse, well-graded, sands with an artificial bond, such as dextrin, flour, treacle, syrup, etc. It would be a much easier problem to enumerate the British resources of high-silica sands. Most are used also for glass-making, and so have been described in a recent Memoir, published at the instruction of the Ministry of Muntions, "Sands Suitable for Glass-making, with Notes on Certain Crushed Rocks and Refractory Materials," Longmans, Green & Company. The chemical and mechanical composition of these are easily determined.

Dominating the whole discussion is, of course, the question of economics. It is desirable, at the present time, to find suitable sands as near as possible to the works in order to reduce transport to a minimum. When hostilities have ceased, it will rather be a question of the cheapest source of supply. Few, if any, refractory sands need be imported into the British Isles from abroad. We can certainly supply most, and when we know our resources better, probably all the moulding-sands we require, for the proper maintenance of the great key-industry which concerns itself with steel. In this matter, as in many others, the British Isles should be self-supporting, and in the future the state of affairs which arose after the outbreak of war as a result of the restriction of foreign supplies should be rendered impossible of repetition.

On the occasion of the celebration of Independence Day by the Belgian community in Millom, Mr. A. Miller, one of the directors of Vickers, Limited, at the Naval Construction Works, Barrow, was made the subject of a presentation in recognition of his services to the Belgians resident in Millom and who are engaged on munition work at Barrow.

Common Sources of Error in Castings.

By Joseph Horner.

Differences in Shop.

This matter receives more attention in some shops than in others. The firms in which the slightest risks of error are not tolerated are those which handle chiefly specialities. Those where less care is taken are generally the jobbing shops in which makeshifts and short cuts are permitted that would not find a place in the other class of foundries. The difference between the two is to be explained thus:—

In the foundries where only single castings, or a few, are made from a pattern, and where, since the cost of the latter has to be borne by the single, or the limited, number of castings made, the outlay on the pattern must needs be kept as low as possible. But when the expense can be spread over a hundred or a thousand castings, it may be, and generally is, the highest economy to make the pattern with the nearest possible approach to accuracy, and also to eliminate all risks of error in the moulding. To those who are not very intimately acquainted with foundry work, it may appear that there could be no differences of this kind, but that a pattern must be either right or wrong, and that the founder must without doubt make a mould precisely like the pattern supplied him. That, of course, is true in a large number of instances, but it is not so in all. It is correct so far as the pattern maker's work is concerned in the case of solid uncored patterns, and in those for which the cores cannot possibly be inserted in an incorrect position; but it does not include that very large section in which cores can be inserted in their print impresssions the wrong way about, nor those in which loose pieces occur, nor in which bosses and prints are indistinguishable from each other, nor in which sound metal is essential.

The Incorrect Setting of Cores.

Many a core being set wrongly in its mould has been responsible for a waster casting. In almost every case of this kind the cause is the lack of foresight on the part of the pattern maker. A moulder has not the advantage of the perusal of the drawings. Often he can have no notion of the function of a casting, or of the reasons for its details. And if he does sometimes appear to go out of his way to commit a blunder, there is a good deal of this cussedness in human nature. It is a trite saying, that if it is possible to insert a core the wrong way, the moulder will do so. Whether this be an unkind libel or no, it should lie with the pattern maker to prevent risk of such blunders occurring. They are all preventable, and are guarded against systematically in shops where specialities are handled. Though the cost of the pattern work is increased, it is amply repaid. Safety is secured by the adoption of a kind of block system, in consequence of which the impression of a core print can only receive its core in one way—the right one, no other being possible. Methods vary in different kinds of jobs, but there is never any difficulty if the practice is insisted on as an essential part of the system of the shop. It is of high value in a firm's own foundry, by rendering unnecessary the frequent summoning of the pattern foreman to show how a core is to be placed in a mould. But it is much more an essential element of safety in the case of work which is sent out to other foundries, frequently in distant towns, to be cast either in iron, steel, or gunmetal. The following remarks will indicate the usual character of the methods that are adopted.

A common cock plug, having a central core and water-ways through the body, has its core carried with prints at the sides in addition to those at the ends, the side prints being included in order to ensure that the water-ways shall come in correct relations to the square neck of the plug on which the spanner is fitted. But these side prints are unnecessary, and they increase slightly the risk of a crushed mould over the core prints. If the side prints are omitted, it is only necessary to cut a flat on one of the end prints, and insert a similar flat in the core box. The moulder must then insert the core with its flat to match that of the core print, and the openings must come in their correct locations.

The same method is also frequently adopted when coring out cotter-ways, being equally suitable for coring them at any angle in the mould, including a diagonal position. If they stand either up or down, or horizontally, core prints can, of course, be used, but it is, as a rule, desirable to lessen the number of prints when that can be done without incurring risks of inaccurate setting of the cores. The reasons for this are the risks—though slight—of the crushing of cores, or of moulds in contact with cores—more dangerous in dried sand than in green, of gases being entangled in the cores, of metal getting into the vents, and of the formation of fins. Hence the more extensively work is standardised, the more the care that is devoted to the setting and the fixing of cores, and the multiplication of prints lessened as far as is judicious.

Another example of this kind occurs in standard patterns for the bodies of lock-up safety valves, in which the slot openings for the lever are cored, though no prints are put on to indicate their position. A flat is cut on one of the circular core prints, and a flat is put in the box to correspond, the holes for the lever being cut in the main box, and terminating with the outside metal.

An example of another kind is one in which internal portions of a core made in more than one piece have to occupy correct relations to each other, as well as to the outside of the casting. Many such cases occur in cock and valve work, and in these the insertion of a flat register affords security. Another method frequently adopted is to cut one corner off a rectangular core when the core must fit into the mould in only one position. This happens when prints for other cores are fitted in the box, or when brackets, flanges, bosses, etc., are carried in the main core.

The mere fitting of cores into their print impressions is not, in a system of specialised manufacture, left to be done by the file or the rubber of the moulder. Though this does not entail any serious risk of displacement, it occupies some time, which mounts up when large numbers of castings are concerned, and therefore the taper is put once for all in the core box.

Loose Pieces.

Another class of risk arises from the employment of loose pieces—a large and constantly recurring group. Those which are studded or dowelled on the top of a pattern may become shifted in consequence of inserting the dowels into the wrong holes, the loose piece being turned about. If, for example, a top print is set centrally on a cylindrical piece, or is set eccentrically on a deep ring from which pistons are parted off, incorrect setting may result. If the dowel holes are not located equidistantly on a centre line in the first example, the print, if reversed, will lie eccentrically. If it were turned about in the second case it would not give the correct amount of eccentricity. The error might be such that a moulder would not detect it, yet be sufficient to take away the allowance for tooling on one side. In such cases the prints and pattern face may be marked with a cross, cut deeply, or a letter stamped to show the direction in which the print must lie. In the case of a central print, one central dowell is sufficient, and is safe. The case of top flanges dowelled on is similar. To prevent risk of error in setting, the dowel holes may be equidistant, or a shallow recess can be cut for the flange to drop into, so that it cannot be turned end for end.

Loose pieces on the sides of patterns are usually attached with skewers. These, too, can easily be set incorrectly, by turning them about, excepting in the case of circular bosses or prints, which are held with a single skewer inserted centrally, which is the proper way with these. But flanges, strips, bracketings, etc., can be turned end for end accidentally, unless the shapes are so obvious as to preclude the risk, or unless the skewers and holes are placed so as to render the turning about a matter of indifference, which can only apply in a few instances. Or, again, the proper location may be clearly indicated by scribing deep lines round the piece on the pattern face, or by stamping letters, or cutting figures or other marks deeply with a chisel and gouge.

When loose pieces occupy the lower edges of patterns they can be attached either with sliding dovetails or by insertion into shallow recesses, say 1-16 in. or ⅛ in. deep, supplemented in the latter case with skewers. Both prevent risk of wrong setting. Dovetails occupy a little time in making, and they are just slightly liable to stick when a pattern lies long in the sand, but which may be prevented by rubbing them with powdered blacklead. Skewer holes in old patterns may become filled up with sand and be overlooked, and the loose piece be omitted. But dovetails, or a shallow recess, indicate the place that a loose piece has to occupy, shown by the presence of these mute reminders.

Bosses or Core Prints.

Another source of error arises from the mistaking of prints for bosses. A plain boss is not distinguishable from a core print of the same dimensions, so that sometimes instead of a round core in the casting a solid lump appears on it. For this reason, in a standardised system of patterns, prints are painted or varnished a distinctive colour—black usually, so that error cannot arise.

Tooled Portions.

It is also usual in standardised work to varnish areas that are to be tooled, red, in order to indicate to the moulder that those areas must be cast downwards, or, if not, that special care must be taken to have clean metal in those localities. This is promoted by running it through a skimming chamber, or by employing flow-through risers, or by thorough melting and skimming of the metal, or by all in combination. When possible, however, these faces should be cast downwards. When tooled portions occur in the top as well as in the bottom the other precautions must have more special attention, and, where suitable to the casting, pouring on end with the inclusion of head metal is an alternative.

The Effects of Shrinkage.

The shrinkages of metal affect not alone the allowances which are imparted to the patterns in excess of the casting dimensions, but also the shapes of some patterns, neglect to allow for which will result in misshapen, weakened, or fractured castings.

There are numerous sections which, if made from a straight pattern, will not remain straight after cooling and for these the patterns have to be curved or cambered to the same amount, but in the opposite direction. And camber is also a very uncertain and delusive quantity, being so tricky that very slight alterations will modify its amount, or change it from positive to negative. But it has to be met, and considerable experience is essential on the part of those who would make the allowances that are necessary to counteract it.

Ordinary shrinkages again cause trouble in producing warping and even fracture of castings, Collaboration between the pattern maker and moulder might frequently eliminate faulty designs. Every man of experience can recall many instances in which castings have either broken or, to certain knowledge, have remained in a tense and unsafe condition, because of disproportion between adjacent parts, by which some portions, because of severe shrinkage, hold other parts in permanent tension. The observant moulder often saves such castings by the expedient of uncovering and cooling off heavy bosses before the lighter portions which are tied to it have become cold and rigid, or, again, by cutting large radii or fillets in places where shrinkage pulls are excessive. The man who is "not paid to think" ignores such precautions, but simply fills his mould, and leaves it to take its chance. Primarily it lies with the pattern maker to realise and check errors in proportioning, and to have the design modified on safe lines.

Variations in the Dimensions of Castings.

The causes of these are rapping and delivery, mending-up and repairs, rubbing cores, and the pressure and action of metal. Each of these is a variable, the quantity of which depends on size, and on relative proportions, as well as on the human element. The marvel is rather not that the dimensions and weights of castings moulded from the same patterns are not all alike, but that they do not vary more widely.

Rapping and delivery are obvious causes of variation, being readily seen. When a moulder raps against a loosening bar with a hand-hammer, or a labourer hits it with a sledge, until the pattern is loosened to the extent of from 1-32 in. to ⅛ in. all round the top edge, the enlargement is apparent. The deeper the mould is, the more severe is the rapping. The smaller the amount of taper imparted to the pattern, the more rapping must be done. The more roughly the pattern is

made, and the more uneven are its sides, the more severely must it be rapped. If timber joints have started, with slight overlapping, or if grain is roughened up by moisture, or if screw or nail heads project slightly, these faults must needs be counteracted by increased rapping. For these reasons metal patterns, and the mechanical lift of a machine, are to be preferred if uniformity in dimensions is desired. The metal pattern remains permanently smooth, the very minimum of draught can be imparted to it, no lateral rapping is necessary to cause permanent enlargement of the mould, but only vibration or jar to loosen the contact and pressure of the sand, and a stripping device to prevent the sand from being pulled up along with the pattern. Made under these conditions, all moulds measure nearly exactly alike, the human element being eliminated. But still there remains the fact that metal patterns and machine moulding only include a minority of the work done, and scarcely touch that of medium and of massive dimensions, in which, therefore, all the above-mentioned faults, singly or collectively, are liable to occur.

Mending up and repairs to moulds are a necessary result of the fracture of sand consequent on rapping, and forcible withdrawal of patterns. Should a machine-made mould break down, it is usually easier to knock it out and make it over again than to attempt much mending up. In small work, the pattern may be put back into the damaged mould, and the sand made good round the pattern; but that is not practicable when patterns are large and intricate. In these cases, portions of the pattern may be removed and put back as guides by which to mend up; or separate pieces may be supplied for the purpose, or any suitable strips, flat or otherwise, be picked up at random, and used as guides against which to make the broken sand good. In all hand-moulded work, even if done by a careful man, accurate results cannot be expected when broken sand has to be mended up. For it often entails more than the mere replacement of sand. Nailing has to be done in some sections in order to secure the repairing sand to the solid mould, also cutting and hatching up with the trowel with the same object, the employment of clay water to help adherence, slight amounts of ramming, sleeking, and finishing with the trowel, followed by skin-drying. When the pattern parts cannot be put back, all this is conducive to inaccuracy, the only guide being the unbroken portions of the mould, and the eye and hands of the workman.

The worst cases of fractures occur in deep sections coming up in the top parts of moulds; in bedded-in work much making good of sand has to be done, because of the essential difference between bedding a pattern into sand, and ramming sand directly against its face. All loose portions have to be made good with additional sand pressed in with the fingers and hands, or rammed and sleeked. The abuse of hard sleeking in all moulds is responsible for enlargements, or scabbing.

Rubbing Cores.

When a large mould contains numerous cores, the weight of the casting may be easily increased by the practice of rubbing the cores over to smooth down the roughnesses previous to blackening. A flat piece of wood is used for this purpose, or often a rasp, and a core quickly becomes reduced thereby. If thicknesses are not checked in the mould, castings may come out much too heavy from this cause.

Pressure of Metal.

This also is a fruitful cause of increased weight when castings have large areas with flat expanses of metal. The result is due to the straining or lifting of the top box by the hydrostatic pressure, and this causes the metal to become thicker than the unstrained mould would show. An $\frac{1}{8}$ in. is not an unusual excess over a large area. And thickening may occur over the bottom, but from another cause—that of too soft ramming, in which case the surface will be lumpy, consequent on the pressure of metal over the softer areas. This is an evil which is common in bedded-in work. Thickening in the top can be prevented if the central areas are sufficiently loaded with weights. It is also customary to reduce the thickness of plated portions of patterns that come in the top by 1-16 in., or more, with the certainty that the casting will come out at its correct thickness.

The Action of Metal.

Besides the pressure, the effects which result from the temperature of metal, and from the ways in which it is brought into moulds, produce sound or faulty castings. Hot metal, dull metal for heavy moulds, metal well melted and skimmed, runners and risers adapted to their moulds, bringing metal in where it has a clear passage way, the avoidance of contact with cores and weak sections of sand, feeding of some moulds; each or all of these have to be regarded if sound results are to be secured.

OIL FUEL IN MEXICAN IRON AND STEEL WORKS.—In the plant of the Compania Fundidora de Fierro y Acero of Monterrey, Mexico, oil is now used as fuel for the boilers, open-hearth furnaces, and the furnaces in the rolling mills. An analysis of the crude Mexican oil in the market gives the following percentages:—Carbon 82.70, hydrogen 12.20, oxygen 0.40, nitrogen 1.70, and sulphur 3.00 per cent. Its density is 16 to 20 Bé.; its average specific gravity 0.936. Its calorific value is 4,680 heat units The oil is consumed at the following rates in the different furnaces. The open-hearth furnaces turn out three charges in twenty-four hours, and consume 147 litres (32.34 gallons) per metric ton of finished steel when dealing with cold charges, and 121 litres (26.62 gallons) per ton, with four charges per 24 hours, when one-half of each charge consists of molten metal, and the other half scrap. The proportion of the oil consumption to the former gas coal consumption is 473 litres (104 gallons) of oil to one metric ton of coal, the heating value of which was 2,918 calories. The furnaces in the rolling mills show an exaggerated consumption, as the mills were only working twelve hours a day, and the furnaces had to be kept alight for part of the night. Moreover, the bar mills only received cold blooms and billets, and some of the blooms received by the joist mills were also cold. The oil consumption in the blooming mill, therefore, varied between 60.5 and 83.2 litres (13.31 and 18.30 gallons) per metric ton of blooms. The proportion to the gas coal formerly used was 492 litres (108.24 gallons) of oil to one ton of coal. In the rail and joist mill 87 litres (19.14 gallons) of oil were consumed per metric ton of rolled products, and 85.2 litres (18.74 gallons) per ton in the bar-rolling mill. The oil consumed in producing steam for the vaporisers is included in the fuel for boilers. There are 13 Babcock & Wilcox "400 h.p." boilers, the oil consumption of which can only be given in proportion of the coal formerly burnt; it amounts to 548.8 litres (121 gallons) of oil for every ton of coal formerly used. In this quantity the amount of oil for producing steam for the vaporisers is included.

Electric Furnaces in United States Steel Foundries.

The following are two further Papers read before the recent meeting of the American Electro-Chemical Society :—

THE RENNERFELT ELECTRIC FURNACE.

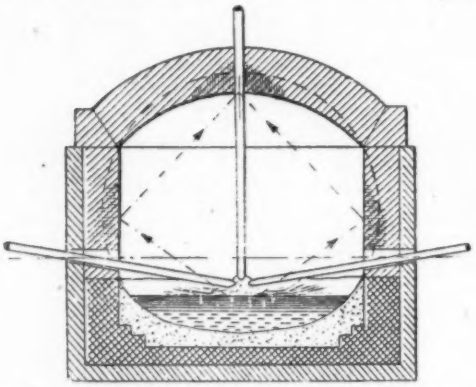
Mr. C. H. vom Baur (manager of the electric furnace department of Hamilton and Hansell, New York) read a Paper on the subject of the Rennerfelt electric furnace, in which he pointed out the improvements made in the design, and consequently in the operation, of the furnace in America during the year 1916. Briefly, he said, these consist of the following :—

The furnace hearth is now circular with one set of electrodes, and oval-shaped with two sets.

The side electrodes are adjustable in a vertical plane, allowing them to dip toward the bath.

The available power for instantaneous available heat has been largely increased

With a circular hearth, and flame in the centre, the heat distribution is equal at the slag line. There are consequently no cold corners, obviating



Tilting Electrodes of the American Rennerfelt Electric Furnace.

overheating when melting, so detrimental to both side-walls and roof. The side-walls, slag line and roof, especially the latter, now dome-shaped, are easier to repair. Often only the centre portion of the roof bricks needs replacing, the other roof bricks lasting twice as long.

In the illustration the shaded portions show how the refractories, either basic or acid, wear out first. The portions of the central part of the roof being directly over the flame would naturally wear more there, and it seems that this is accentuated by reflection from a too-thick slag first reflecting from the side-walls, substantially as indicated by the broken lines. The dotted lines show the tendency towards eventual wear.

The second feature, tipping the side electrodes down from a horizontal position, has several advantages. When smaller charges than normal are made, the most efficient height over the metal when melted can be maintained. During melting, the electrodes at the start, whether for partial or full heats, are usually only an inch or so over the bath. As the charge melts the electrodes are continually lowered, thus keeping the flame about 2½ to 3 in. over the bath. Bringing the flame closer to the bath accomplishes two things: The melted steel more readily absorbs the heat, and the large flame, being farther away from the roof, lengthens its life. This is proved by the shorter time to make a heat from a cold charge and by a longer life of the roof.

The possibility of tilting the electrodes up and down helps when slagging off, and lessens the breakage of electrodes. The flame nearer the bath, and with the same potential, has a tendency to circulate the slag faster. This can easily be observed, and is of the greatest importance. A more shallow bath facilitates the refining, as the metal comes in contact with this slag on a larger surface.

The flame itself, depending on the size and electric power of the furnace, seems to make a circular patch on the thinned slag directly beneath the flame about 8 or 10 in. in diameter, and then mushrooms out. The hotter the furnace the better the conductivity of the gases and the greater the spreading of the flame. In a two-flame furnace this flame at times seems to spread over the entire bath. This appearance is, no doubt, due to incandescent gas. The hearth is made more shallow, and thus the rammed-in bottom coming up at the sides makes the sides less steep. This shallow bath shortens the time of melting down, and the lining is less affected at the slag line.

The regulation of the heat applied to the bath is made easier by the variable position of the flame above it, and it also lessens the danger of overheating, which is apt to become so detrimental with an acid bottom. The ease of avoiding overheating is of first importance.

Having the electrode tips never more than 3 in. above the bath has materially reduced the time of melting. Thus far no Rennerfelt furnace in the United States is using fluid charges. With basic bottom the dephosphorising time has remained unchanged, and the desulphurising period, with the aid of calcium-carbide slags, has been reduced. When refining and reducing sulphur with a built-up slag from ferro-silicon and lime, as used in the induction furnace, this was accomplished with good effect.

With furnaces having 300-kw. power per ton of output, heats have been made on basic bottoms, taking off one slag in 2½ hrs. with 670 kw.-hours per ton when operating continuously. With acid bottoms and 200-kw.-power per ton of output, taking off one slag, good steel and full heats have come off in 3½ hrs. with 635 kw.-hours per ton.

The electrode consumption is less than 6 lbs. per ton of steel made, operating continuously. Even with the present excessively high cost of refractories, this cost has been reduced in the smaller furnace of 1 ton from $2.91 (say 12s.) per ton of steel made to less than 80 cents (3s. 6d.) per ton. Roofs are lasting over 100 heats, and approximate the longer life made in Europe with better refractories. With a higher power input the heats are shortened, due to the smaller melting period (the heat being considerably reduced during the refining time); thus roofs are lasting more heats than formerly, though the actual time is not much changed. Side-walls of brick outlast two or more roofs, while the bottom lasts a year or two.

The third change, to higher-powered furnaces.

besides lowering the cost per ton in every way, steadies the consumption of electricity, which has already been very constant. For instance, a 3-ton furnace operating with 600 kw., with hand-regulated electrodes, will reduce in four or five minutes to about 550 kw. without any fluctuation (except during the first part of the melting period) and without touching the electrode-regulating mechanism. With smaller furnaces the steadiness is not so marked, whereas with still larger ones the effect is but little improved. The power factor is about 90 per cent. with 60 cycles. All sudden strains on the power supply are avoided. The arc voltage has been raised, and is now 110 to 120.

In general, too much stress cannot be laid on the various small details, such as tight doors and tight openings around the electrode-cooling boxes. With the latter, besides a small clearance between the cooling box and electrodes, asbestos washers help materially.

Regarding non-ferrous metals, the results already published have frequently been duplicated and in some instances bettered. For instance, railroad journal-bearing metal (70 per cent. copper, 10 per cent. tin, 15 per cent. lead, and 5 per cent. Zn, Mn, Fe, and impurities), was melted in a hot furnace in 29 min., and with less than 160 kw.-hours per net ton (2,000 lbs.). Aluminium-nickel alloys were melted in less than 15 min., consuming about 300 kw.-hours per net ton.

ELECTRIC HEATING FOR CORES.

A Paper on this subject was presented by Mr. C. F. Hirshfeld (chief of the Research Department of the Detroit Edison Company). He remarked that those who had become familiar with the various uses of electric furnaces of one sort and another had come to recognise the fact that, in a general sense, the electric furnace could not be considered a commercial competitor of furnaces heated by combustion. If this was true of high-temperature processes such as were commonly associated with electric furnaces, it needed no argument to prove it true for low-temperature processes in which combustion methods had a greater advantage on an energy cost basis, because of the lower temperatures at which the products of combustion could be discharged. This condition was frankly admitted, and it was not his intention to urge the general substitution of electric heating for combustion heating in low-temperature processes in general, or in some low-temperature processes exclusively. There were certain low-temperature processes which, in certain circumstances, could be conducted to better commercial advantage by means of electric heating than was possible by means of combustion heating, and it was his purpose to point out some of these processes, some of the phenomena connected therewith which indicated the advisability of heating electrically, and some of the possibilities which electric heating unfolded.

The term "low temperature" was not exact, but for present purposes might be taken as referring to temperatures below about 290 deg. C. (554 deg. Fah.). Such temperatures were below practically all commercial metal-melting temperatures, but were common in numerous baking and drying operations which formed a surprisingly large part of industrial processes.

The best example of the extensive adoption of electric heating for low-temperature work was furnished by the electric japanning equipment installed during the past few years. An equally promising field existed in foundry core rooms. The baking of foundry cores, continued the author, is at present a most haphazard process in the majority of foundries. A casual inspection of one batch of exactly similar cores will generally show colours varying from a light tan or even lemon yellow to a dark chocolate brown. One of the numerous varieties is certainly better than all the rest, and it would seem desirable to determine which one is the best for a given set of conditions and then to make all of them like it. Preliminary experiments conducted for the purpose of discovering whether the essential properties of cores varied as greatly as their colours gave most astounding results. Strength was taken as reference in this case, although admittedly it is only one of numerous properties which must be considered in defining a perfect core.

One set of experiments was made upon exactly similar cores, made of the same materials and tamped to the same extent. They were baked at different rates and also with different maximum temperatures. Curves of strength plotted against time of bake and also plotted against maximum temperatures were sharply domed in all cases, and showed variations of several hundred per cent. in any one case. Samples of these cores were shown to experienced foundrymen after rupture so that both exterior and interior were visible, and they picked out as good cores which had shown relative variations of over 100 per cent.

Another set of experiments were made to determine the effect of air circulation. Again a number of exactly similar cores were tested. Baking methods were alike in every respect, excepting for the quantity of air drawn over the core during baking. Strength of core was plotted against quantity of air passed in unit time, and again a sharply domed curve was obtained. Apparently, excess air is detrimental, though not to the same extent as a deficiency of air. What is more important is the demonstration that some definite quantity of air gives the best results.

It seems probable that investigation will show that porosity, brittleness, character of surface, and all the other properties which must be considered in connection with cores will be affected in some such way as strength has been shown to be affected by the variables studied. If this is true, it certainly seems as though the foundries which carefully study their production methods and costs will ultimately demand more perfect control of the core-baking process. When this time arrives it seems probable that electric heating will play a part similar to that which it has played in the japanning field during the past few years. As a matter of fact, there are now in operation several electrically-heated core-baking ovens, and their users all appear highly enthusiastic over the results attained.

The core problem appears to be one of the most promising fields for combined chemical and engineering investigation, and the author feels certain that improvements such as those shown possible in japanning will appear insignificant in comparison with those which are possible of attainment in the core room. Japanning and core baking have been used as examples because of the tremendous extent of both of these industries, and because it happens to be possible to record the results of a small amount of experimental work in both of these fields. It must not be assumed, however, that they represent the only possibilities for the application of electricity to low-temperature baking.

Moulding Water-Ballast Rollers.

By A. B. Smith.

Some time ago the writer had the opportunity of studying closely various methods of doing this class of work, and after a number of experiments the following system was brought about, enabling the castings to be made very accurately, quickly and cheaply. The rolls are made in a manner that requires very little machine work, and after leaving the trimming sheds are practically ready for use; any size can be made, and the rollers are used generally for garden lawns or road rollers, for either hand, horse or power.

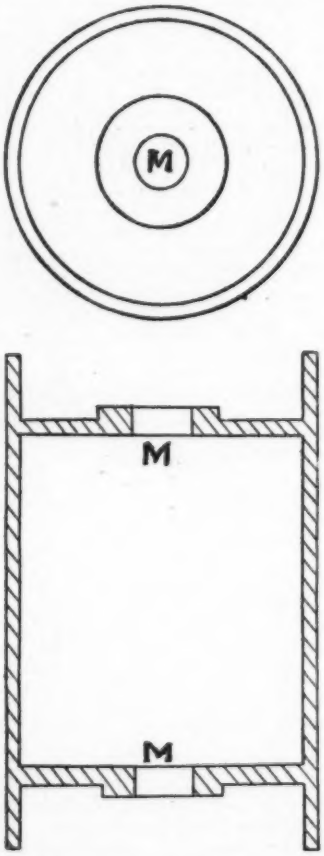


FIG. 1.—PLAN AND SECTION OF ROLLER CASTING.

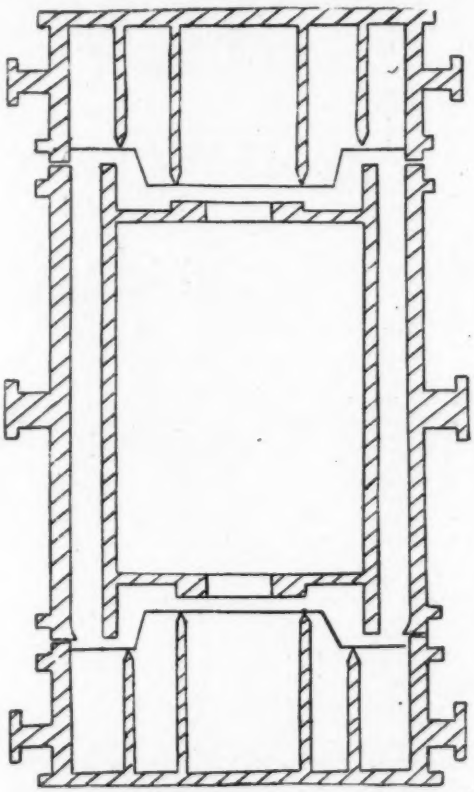
The patterns used are simple in the extreme, a plate pattern forming both ends, top or bottom, as in Figs. 1 at M and 7 at B. The plate (Fig. 7) should be ribbed at the back to prevent warping. The next is the cylinder pattern, Fig. 9, just an ordinary barrel casting open at both ends. This must be the exact length of the roller, and if it is made the same thickness it can be used as the core-box for the body core, thus saving a second pattern. Two holes should be drilled near the top for hooks D, Fig. 9, to be inserted when lifting out or drawing. If this is made from a dry-sand mould and tapered, it should not require machining, but should be well rubbed down with emery stone.

Next is the base or setting-out plate, Fig. 8—just a flat plate ribbed at the back to prevent warping, and machined on the one side only. This is to receive the cylinder pattern and centre-box, which will be explained later.

FIG. 2.

FIG. 3.

FIG. 4.



FIGS. 2, 3 AND 4.—BOX PARTS ASSEMBLED IN POSITION FOR CASTING.

Boxes.

The moulding boxes can be either round or square, but preferably round. They must be necessity be duplicated and have edges machined to ensure accurate fitting. The top and bottom box are similar and flanged (see Figs. 2, 3, 4 and 5). and the stays let down to take the recess as shown in Fig. 7 at B. These stays should be arranged to form a square in the centre as in Fig. 5 at G, so as to assist final coring up and free passage of air when casting, as will be explained later. The centre box part hardly needs any explanations—a glance at Figs. 2 to 4 will be sufficient; but the centre box part should be the exact length of the casting to ensure a level joint

top and bottom. A glance at Fig. 4 will show at once the method of assembling and the position of casting in the mould, the whole being fitted with

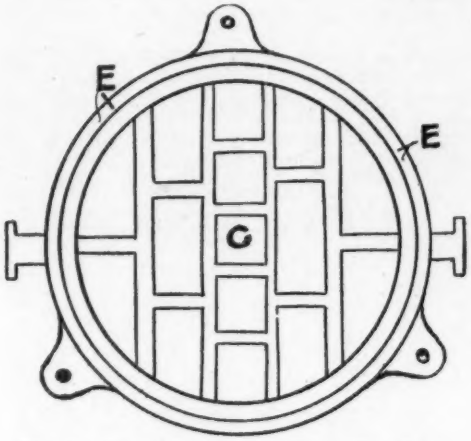


FIG. 5.—PLAN OF TOP AND BOTTOM BOX PARTS.

cotter-pins and lugs in each part, no weighting or bolting being necessary.

Moulding.

The moulding, which is simple, is as follows:—First, cut a bed in the floor and place the pattern-

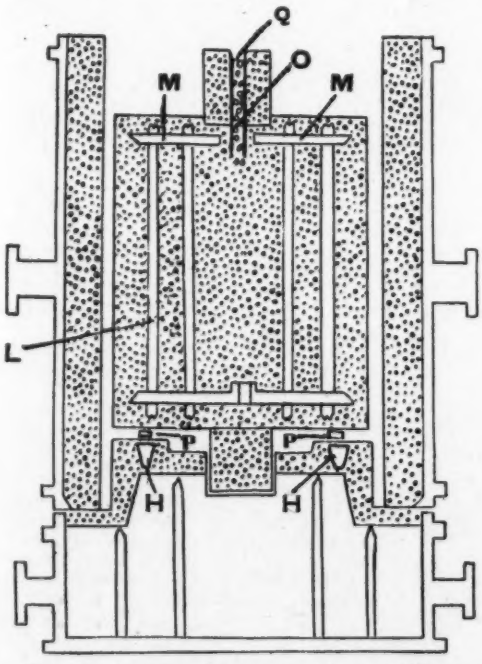


FIG. 6.—SHOWING POSITION OF CORE IN MOULD PREVIOUS TO PLACING TOP MOULD IN POSITION.

plate (Fig. 7) on it, ensuring it is level and lying solid. Next, put on the bottom box part and cotter it down to prevent lifting when ramming. Before proceeding further, obtain three pieces of clean plate scrap and pack under the stays at equal positions to act as bearings for the studs or chaplets to carry the body core, as in Fig. 6, letter H. Now sieve on a layer of facing sand, drawing it up round the sides and boss, Fig. 7, I. Now partly fill up and tuck the stays to ensure there being no soft places. Finish ramming and strike off the surplus sand. Give it a good pricking with a vent wire and roll the whole lot over to a posi-

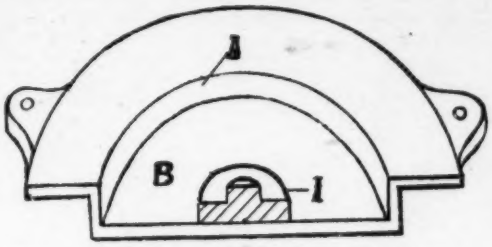


FIG. 7.—HALF-SECTION OF PATTERN PLATE FOR TOP AND BOTTOM MOULD.

tion as nearly level as possible. Then withdraw the cotters and gently rap the plate, which is lifted off by two men and guided straight by the box-pins. Finish off with a little plumbago, and it is then ready to receive the middle mould.

Now place the base plate, Fig. 8, on the floor as before. Then pick up the cylinder pattern, Fig. 9, and place it on the base-plate over and down the three studs, J, Fig. 8. The studs prevent the pattern moving, and also bring it central with

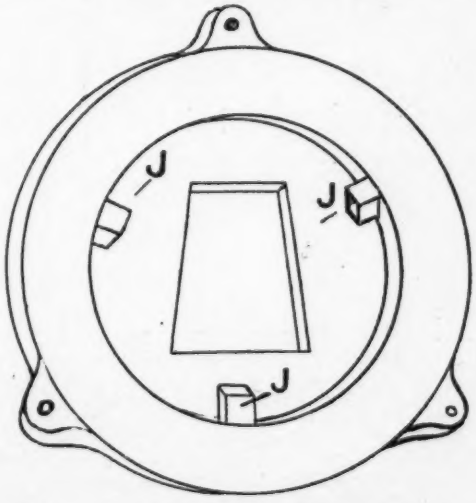


FIG. 8.—SETTING-OUT PLATE FOR RAMMING UP OUTSIDE MOULD AND CENTRE CORE.

outside box. Take a swab of paraffin and rub it down to prevent clogging when being drawn; then place the box, Fig. 3, over and on the plate, lugs and pins corresponding. Sieve a small heap of facing and use sufficient to bring up to about 8 in. or 1 ft. up the outside of the pattern. Thoroughly mix a barrowful of good floor sand with a shovelful of coal dust and sieve through a quarter riddle, no more facing sand being necessary. Ram

up well to about two-thirds of pattern, then finish ramming lightly, or with a shovel handle. In striking off the joint a good " tip " is to get a circular piece of tin, the same diameter as the outside edge of the pattern, and lay this on top before commencing ramming. Then pile with sand and feed it in as the ramming proceeds. Now withdraw the pattern and finish the mould with roughing the surface with the palm of the hand, sleeking down with a trowel, or pipe-sleeking tool; release the cotters and lift the box from the plate and place into the bottom mould as in Fig. 6. The top mould is made exactly the same as the bottom, except for the bearings of the chaplets which are left out, and a piece of pipe rammed up over the core print being removed previous to turning over.

Making the Body Core.

Place an ordinary plate on three bricks on the floor, or any convenient position. Place the cylinder pattern on this. Put in a layer of core-

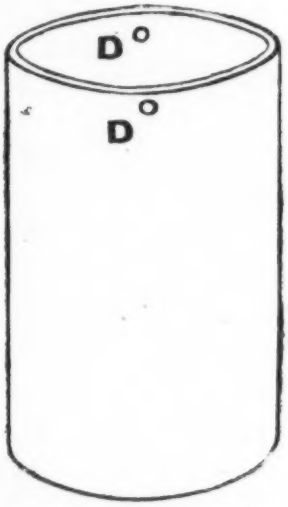


Fig. 9.—Cylindrical Pattern for Centre Mould and Core.

sand about 1½ to 2 in. Next take the core-grid, Fig. 10, and screw in the centre the eye-bolt, K, Fig. 10. Clay-wash the grid and lower inside the pattern, gently tapping all round to ensure a good solid bed. Now continue the ramming up to about 6 in. Next take some straight pieces of iron and stand in as in Fig. 6 at L. These should be nearly the length of the core; the reason why they are not cast in the grid is to simplify extraction when cleaning the casting. The ramming and venting may be proceeded with up to nearly the top after putting in the necessary amount of coke or ashes. Now put in the top grid, over the straight irons, as in Fig. 6, M. The depth of the top of the core is determined by a strickle, and the thickness desired in the casting, Fig. 11, N. Finish off with a good venting. Now rap the outside of the pattern and lift off, still keeping the eye-bolt in the core. After a few hours' drying, the core may be lifted off the plate and three bricks placed on the plate, replacing the core on the bricks, when the drying will be more equal and quicker.

Coring up Ready for Casting.

First obtain a piece of round core, the size of which is determined by the size of the hole in the centre of the roller, Fig. 1, M, usually 3 to 4 in. in diameter and in length from the bottom of the print, allowing thickness of the casting to the bottom of body-core as in Fig. 6 at O. Now place three studs, I, in position on the three pieces of plate bearings, as at H and P, Fig. 6, thus forming a level seating for the main core, which can then be lowered into position and the eye-bolt removed. Having ascertained the thicknesses are

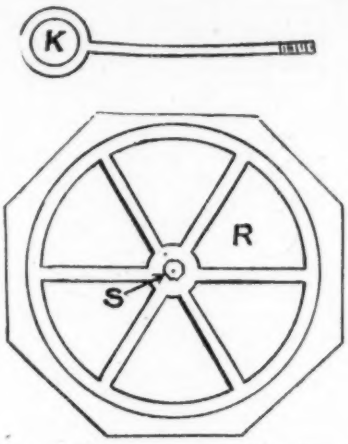


Fig. 10.—Core Grid and Lifting Eye Bolt.

equal, next take a piece of core as in the first place at O, Fig. 6, rubbing a large centre vent to bring off the air from the body core, Q, Fig. 6. Add a thin layer of oily blacking to ensure a perfect bed. Now obtain two chaplets with wide heads, say 2 in. square and 6 in. stalk ⅜ round, and push through top mould, which can now be placed on. Having closed the mould, a gate is made by pushing through an inch tube at any suitable place on the plate part of the mould. Now fill up the vent and print with small ashes, as this prevents metal getting in the vent and at the same time allows a free passage of air. The chaplets can be fastened by a flat bar extending

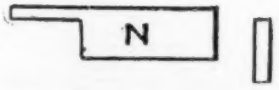


Fig. 11.—Strickle for Forming Bars on Centre Core.

across the box to the flanges and cramped to the flanges. Use a large runner basin; no riser is necessary.

Core Grids.

The core grids are cast open-sand from a board pattern as at R, Fig. 10. The bottom grid has a ¾- or 1-in. nut cast in the boss as at S; the top grid, a piece of core, allowing passage of lifting eye-bolt. The rate of moulding in pre-war time was three 36 by 20 rollers a day, 3s. each, including the core grids. Working a 9-hour day, we always had an hour or hour and a half to spare.

Refractory Materials.

At a recent meeting of the Institution of Gas Engineers the Refractory Materials Committee submitted a report, to which the following two papers by J. W. Mellor, D.Sc., were appended :—

Hot and Cold Sizes of Firebricks.

The object of these experiments was to get an idea of the difference between the hot and cold size of typical firebricks as they occur on the open market. The measurements on the whole brick were made with Coppée's apparatus. Two cuts are made in the brick; each cut is intended to hold a pointed platinum wire. The two saw cuts are arranged so that the wires fit tightly. The distance apart of the tips of the wires is measured while the brick is cold (15 deg. C.) by means of a cathetometer provided with an invar scale. The brick is heated in a furnace to the desired temperature, and, by means of suitable apertures in the furnace, the distance apart of the wires is measured again. The results are indicated in Table I.

TABLE I.

Laboratory mark.	Type of brick.	Distance between platinum wires. Before firing.	Distance between platinum wires. After firing.	Percentage expansion.	Linear coefficient of thermal expansion.
		Cms.	Cms.		
A1	Silica brick ..	17.95	18.05	0.56	0.0000048
A2	Firebrick ..	18.78	18.87(5)	0.51	0.0000044
B1	,, ..	20.31	20.45	0.69	0.0000059
B2	,, ..	19.43	19.50	0.36	0.0000031
B3	,, ..	20.06	20.25	0.95	0.0000082
C1	Silica brick ..	20.29	20.43	0.69	0.0000059
C2	Firebrick ..	19.83	19.94	0.55	0.0000047
C3	,, ..	19.80	19.92	0.61	0.0000052
D	,, ..	19.01	19.06	0.26	0.0000022
E1	,, ..	18.35	18.42	0.38	0.0000033
E2	,, ..	18.68	18.80	0.64	0.0000055
F	,, ..	1854(5)	18.66	0.62	0.0000053
G1	,, ..	18.77	18.83	0.32	0.0000028
G2	,, ..	18.29	18.41	0.66	0.0000057
H	,, ..	18.71	18.84	0.70	0.0000060
J	,, ..	19.41	19.53	0.62	0.0000053
K	Red silica brick	19.29	19.46	0.88	0.0000076
L1	Silica brick ..	18.27	18.41	1.77	0.0000066
L2	,, ..	18.52	18.78	1.40	0.0000121
M	,, ..	18.85	18.94	0.48	0.0000041
N1	Firebrick ..	18.53	18.66	0.70	0.0000060
N2	,, ..	18.84	18.98	0.74	0.0000064
O	,, ..	18.89	19.06	0.90	0.0000177
P	,, ..	19.50	19.70	1.03	0.0000088
Q	,, ..	18.93	19.07	0 74	0.0000064
R	Magnesite brick	18.39	18.66	1.47	0.0000126

If the brick is imperfectly burned, there is superposed on the effects of thermal expansion an after-contraction or after-expansion. In consequence, in the former case the results are too small, and in the latter case too large. Still further :—

(1) The brick does not contract to its original volume on cooling. The difference between the cold sizes of the brick before and after firing shows the magnitude of the after-contraction or after-expansion, when the brick was heated under conditions of the experiment.

(2) In all cases of after-contraction (or, *mutatis mutandis*, after expansion), the brick may show a smaller volume at, say, 1,180 deg. C. than it does at, say, 1,060 deg. C. This shows that the effects of thermal expansion are altogether masked by the after-contraction. Thus :—

Distance of wires at ..	15° C.	18.72 cm.
,, ,, ..	1,060° C.	18.80 cm.
,, ,, ..	1,180° C.	18.75 cm.

It was only when the whole of the cold and hot measurements were under consideration and were being extended to different temperatures that the dual character of the phenomenon was discovered: and it has made the Committee suspect these and other measurements of the coefficients of thermal expansion of refractory materials at high temperatures—unless it can be demonstrated that the results are not affected by the error under consideration.

These measurements also show that the coefficient of expansion of fireclays and of silica bricks decreases with rise of temperature. Thus, in two cases :—

Silica Firebricks.

	I.	II.
From 15° to 940° C. ..	0.0000060	0.0000081
From 15° to 1,180° C. ..	0.0000060	0.0000060

Silica Firebricks.

From 15° to 940° C.	0.0000051
From 15° to 1,180° C.	0.0000064

It will be observed that the coefficient of thermal expansion represents the average increase in length which a brick undergoes when unit length is heated 1 deg. C.; so that a 9-in. brick with a coefficient of 0.000005 will be 9 (1+0.000005 × 1,200), or 9.054 in. long at 1,200 deg. C. Otherwise expressed, a brick 2½ in. thick when cold will be 2½ (1+0.000005 × 1,200), or 2.515 in. thick at 1,200 deg.; or, neglecting the jointing cement, sixty-six bricks piled one on top of the other would expand 1 in. when heated to 1,200 deg.

An Examination of the After-Contraction or After-Expansion of Firebricks in Oxidising and Reducing Atmospheres.

It is well known that ferrous iron has a far greater fluxing action than ferric iron, so that the contraction of a brick fired under reducing conditions will probably be greater than when fired under oxidising conditions, providing no bloating occurs. Nearly all firebricks are burned under oxidising conditions. It therefore appeared of interest to find the difference in the results obtained in the specification contraction test when conducted under oxidising and under reducing conditions. Some measurements are given in Table II.

C signifies contraction, E expansion; the specimens marked with an asterisk were fired at cone "12" for two hours, and the others at cone "14." See standard specification.

These results show a general tendency for silica bricks to give a less expansion in a reducing atmosphere than in an oxidising atmosphere; and for (fireclay) firebricks to give a greater contraction in a reducing than in an oxidising atmosphere. This result might have been anticipated, because it is in agreement with the much greater fluxing effect of "iron" in a reducing than in an oxidising atmosphere.

TABLE II.

Type of brick.	Percentage after expansion or contraction (means of duplicates). Oxidising atmosphere.		Reducing atmosphere.	
Silica brick, unusually fine grained	0.44	C	0.77	C
Silica brick, high in "iron" ..	0.58	E	0.48	E
Firebrick	0.21	E	Nil	—
,, ...	Nil	—	0.33	C
,, ...	1.12	C	1.27	C
Silica brick	0.20	E	0.13	E
,, ,, ...	0.13	E	0.12	E

The magnitude of the fluxing effect induced by the reducing atmosphere depends upon a number of factors. For example: (1) It depends upon the strength of the reducing atmosphere; that is, on the proportion (and kind) of reducing gases in the given atmosphere; (2) it will also depend upon the rate the gases penetrate into the interior of the brick, and this in turn depends

upon the character of the superficial skin and on the porosity of the brick; and (3) on the time and temperature the brick is bathed in the reducing atmosphere. It is, therefore, difficult to get comparable results with the contraction test under reducing conditions. This agrees with some previous results obtained by determining refractory tests under reducing and oxidising conditions.

For similar reasons, a neutral (or slightly oxidising) atmosphere was prescribed for the refractory test, until further experiments showed how this source of variation could be eliminated. It would be unwise to prescribe a test which gives variable results. It is expected that further experiments on this subject will be ready for the next annual report; meanwhile, it is recommended that the "contraction test" be conducted like the refractory test—that is, in as nearly a neutral atmosphere as practicable.

All measurements the results of which are given in these appendices were made by Messrs. C. Edwards and A. Rigby.

Electric Furnaces for Melting Ferro.

Melting down charges of ferro-manganese in a 3-ton Nathusius electric furnace gave Dr. F. Bittner, of Breslau, an opportunity to make measurements for the purpose of ascertaining the efficiency of the furnace. He has published the results in "Stahl und Eisen," from which the subjoined extracts are derived.

In the furnace three-phase current is employed and can be used of any convenient frequency. There are three pairs of electrodes. The three top or surface carbon electrodes are connected to the outer terminals of the secondary windings of the furnace transformer, and the mild steel bottom electrodes to the inner terminals of the secondary coil. When working without a booster transformer the bath has to be heated almost exclusively by the electric arc as only about 4 per cent. of the current input go towards heating the bottom. With this system of connection the average load at the arc circuit is about 190 kw., while that of the bottom circuit is only about 8 kw. If, however, the bottom circuit is strengthened by the use of a booster transformer the average load at the arc circuit will be 171 kw., and at the circuit through the bottom electrodes 48 kw., or about 22 per cent. of the total energy input. As the principal advantage claimed for the Nathusius furnace lies in the possibility of heating the bottom, it is recommended to strengthen the bottom electrode circuit by means of a booster transformer. The following table compiled by the author shows the percentages of the total input, producing useful effects and loss respectively:—

Portion of total input.	Kw.-hours.	Calories.	Per cent. of total input.
Used for melting the ferro-manganese	354.0	826,000	42.5
Used for melting the lime and forming slag	7.4	17,300	0.9
Lost in transformers	33.3	77,700	4.0
Do. conductors	58.3	136,100	7.0
Do. water cooling of electrodes	50.0	116,900	6.0
Do. conduits and by radiation, including maintaining the heat of the bath	330.0	770,000	39.6
Totals per ton of metal ...	833.0	1,944,000	100.0

It will thus be seen that the efficiency of the furnace is very low (43.4 per cent.), but in the author's opinion an electric furnace, working with a neutral zone, is eminently suitable for melting ferro-manganese, as notwithstanding the high cost of current the melting can be effected economically and without much loss of manganese, an important consideration when dealing with a deoxidiser. It should also be explained that the molten ferro-manganese was used in connection with a basic Bessemer plant, and had to be kept at a temperature of 1,300 to 1,350 deg. C. in readiness for the purpose.

The loss of manganese was only 0.385 per cent., a negligible quantity. The costs of melting a metric ton of ferro-manganese in the electric furnace are given as follows:—

	s.	d.
Current, 833 units	15	0
Electrodes	1	9
Wages	1	6
Depreciation of lining	0	6
Total per ton ...	18	9

Both the primary and secondary windings of the transformers were star-connected. The mean value of cos ϕ was found to be 0.766 for the arc circuit and 0.740 for the bottom circuit.

Metallurgy of Cast Iron.

Mr. A. Stadeler, in recent issues of "Stahl und Eisen," reports the results of experiments carried out by F. Wüst and his pupils with a view of ascertaining the influence of carbon, silicon, manganese, and phosphorus on the mechanical strength of cast iron. Various mixtures were prepared of Swedish charcoal pig, with Swedish horseshoe iron, the silicon, manganese and phosphorus contents being varied by the addition of ferro-alloys. As square or rectangular test bars are liable to develop a white iron at the edges, test bars cast round and turned down were used in the experiments. The quantity and character of the graphite appear principally to determine the mechanical properties, but these are materially influenced also by the pouring and method of cooling. With grey iron containing 1.5 per cent. Si, small quantities of manganese, up to 0.3 per cent., increase the formation of graphite, but a further increase to 2.5 per cent. has no influence. Cast irons high in phosphorus, contrary to existing ideas, may be improved by the presence of 1 per cent. of manganese, or more, provided the rest of the ingredients has been fixed properly. With a rise in the proportion of graphite, the strength of the iron in tension and bending falls off, as a rule. This is also the case with an increase in the percentage of carbon and silicon, both of which favour the formation of coarse graphite. With increase of phosphorus up to 0.3 per cent., and of manganese up to about 1 per cent., the strength in tension and bending increases. Phosphorus up to 0.3 per cent. and also high graphite content enhance the bending strength, while manganese and silicon have the opposite effect. The resistance to specific impact shows the greatest sensitiveness to silicon, manganese and phosphorus. It diminishes rapidly as the phosphorus content rises until this reaches 0.6 per cent., above which the decrease is inconsiderable. This property brings out the superiority of irons low in phosphorus, in respect of resistance to impact, which the tensile and bending tests fail to reveal. Hardness decreases with a rise in graphite content and is increased by a rise in manganese and phosphorus. It does not seem to be affected by the silicon content, but the physical properties of cast iron depend not only on the percentage, but also on the character of its graphite content, and an explanation of the difference in the physical properties of test pieces containing the same percentages of carbon can be readily found by an examination of their micro-structure.

Roll Scale as a Factor in the Bessemer Process.*

By A. Patton and F. N. Speller (Pittsburgh, Pa., U.S.A.).

The use of roll scale in the Bessemer process dates back, to the best of our knowledge, at least 30 years. It was first used by the Ohio Steel Company, Youngstown, Ohio (now the Ohio Works of the Carnegie Steel Company). Two 10-ton vessels and one blowing engine capable of blowing one heat at a time were employed. The object of using the scale was to shorten the length of the blow, or in other words, to increase the production with the same equipment. Various means were tried out for introducing the roll scale into the bath of molten iron. It was soon learned that the proper place to charge the scale was in the empty vessel, so that when the molten iron was poured into the vessel it flowed over the scale, causing a considerable reaction to take place before the heat was turned up. Eventually, cylindrical shutes similar to those now in use were installed. Into these shutes the scale is dumped and carried into the empty vessel. Before this convenient means of introducing the scale was adopted, the Ohio Works had satisfactorily demonstrated that roll scale would increase production, by blowing 107 heats in one 12-hr. turn (1,087 tons) with one blowing engine, blowing one heat at a time; whereas prior to the use of scale, the best practice at these works was about 80 heats under the same conditions.

Experience has shown that the judicious use of roll scale in the Bessemer operation will not only increase production and reduce cost, but that at the same time it will improve the general quality of the steel. Most of the data on which these conclusions are based were obtained at the Bessemer plant of the National Tube Company, McKeesport, Pa.

Influence on Quality.

A higher standard of uniformity, especially in those points which affect the welding quality of the steel, is demanded in the manufacture of steel skelp than for other products. Prominent among the factors contributing to this success is the use of roll scale in the converter. The influence of this practice on quality is primarily due to the wider latitude in silicon which is thereby given to the blast-furnace operations, resulting in higher average silicon and lower sulphur. To obtain uniformly low-sulphur metal from the blast furnace, the Bessemer department must be designed and operated so as to be able to use without complaint iron that will run from 1 to 3 per cent. in silicon. This gives the blast-furnace management a larger margin of safety, thus making unnecessary sudden changes to prevent making iron too hot or too cold for the Bessemer plant. At the steel plant of the National Tube Company the average sulphur in the steel for 1915 was 0.038 per cent. with 95 per cent. under 0.050 per cent.; the blast-furnace iron averaged for that year 1.77 per cent. silicon.

The proper use of roll scale, pig and steel scrap enables the blower to turn down his heats nearer to the same point in carbon by giving a sharper contrast on the final changes in the flame. This makes the loss in manganese and the residual manganese in the steel more constant. It also enables all heats to be blown more nearly in the same time and to the same temperature, which, of course, is favourable to uniformity in heating and rolling and makes all dependent operations more systematic. The introduction of roll scale provides oxide of iron which would otherwise have to be formed by burning about 1¼ per cent. of the metallic charge. Somewhat higher silicon must therefore be present when roll scale is used to make up the thermal deficiency.

Production and Cost.

In the design of a Bessemer plant, about all the engineer can do with regard to production is to make the vessels sufficiently large to blow the size of heat desired, with a bottom having sufficient blast area to blow the heat in a given time. He would probably use in his calculations a pig-iron with 1.00 to 1.25 per cent. silicon. If the blast area was figured sufficiently large to blow iron containing 2.00 to 2.50 per cent. silicon in the same length of time, the operator would be in trouble when required to blow iron carrying in the neighbourhood of 1 per cent. silicon. The vessels would slop badly, increasing the loss, and the quality of the steel would deteriorate. A vessel properly designed, with a bottom having sufficient blast area, using 20 to 25 lb. per sq. in. (1.4 to 1.7 atmospheres) blast pressure and designed to blow a heat of 1 per cent. silicon iron with pig scrap in 10 min., will blow a heat of 1.25 per cent. silicon iron in the same time if steel scrap is used. When the silicon rises above 1.25 per cent., roll scale and pig scrap can be used, increasing the scale as the silicon rises and so continuing to blow heats in approximately 10 min. When the iron runs above 2.00 per cent. silicon, it may be advisable to use steel scrap and roll scale, although the proportions required cannot be laid down according to rule, but must be varied by the operator, depending on mill conditions. By this procedure, heats can be blown in 10 min. which would otherwise require 18 min., thus the full capacity of the plant can be maintained regardless of variations in the pig-iron.

The Bessemer department of the National Works has three vessels 8 ft. in diameter of 9 tons capacity; the bottoms have 18 tuyeres, each having seven holes ½ in. in diameter giving a blast area of 24.7 sq. in. Using 20 to 25 lbs. blast pressure, heats of metal with silicon in the charge ranging from 1.00 to 2.50 per cent. can be blown in 10 to 12 min. As most of these heats carry over 1.40 per cent. silicon, roll scale and pig metal are nearly always used for "scrapping," the roll scale occasionally running as high as 6 per cent. Steel scrap is not used with roll scale as a rule unless it is desirable to blow the heats more quickly, and this usually becomes necessary only when the silicon in iron rises above 2.50 per cent.

The production of this plant has been increased at least 20 per cent. by the use of roll scale in

* From a Paper read before the American Institute of Mining Engineers. Mr. Patton is superintendent of the steel works of the Jones & Laughlin Steel Co., and Mr. Speller is metallurgical engineer to the National Tube Co

this way. For example, the mill records for the month of March, 1916, show:—

Ingots produced, 64,055 tons=7,132 heats.
Charge: 78.4 per cent. direct metal averaging 1.72 per cent. silicon (only one cast was below 1.00 per cent. Si this month, the balance between 1.10 and 2.54 per cent.).
10.0 per cent. cupola metal 1.22 per cent. silicon.
11.0 per cent. scrap consisting of { Steel 2 per cent. / Pig-iron 5½ per cent. / Roll scale 3½ per cent

Delays:

Hrs.	Min.	
50	26	waiting for iron.
6	24	mechanical repairs.
0	8	electrical repairs.
7	50	converting mill delays.
Total 64	48	

Actual operating time=583 hrs. 12 min., or 14¾ min. per heat per vessel is the average time required to charge, blow and pour out each heat.

The sulphur in the steel for the above month averaged 0.039 per cent. with 94 per cent. under 0.05 per cent. The time required to charge the heat, pour into ladle, dump slag, fix stopper, etc., is at least 4 min., which would make an average blowing time of less than 11 min. per heat. This month is fairly representative of current practice at this plant, as the average silicon in metal from the blast furnaces for 1915 and for the first nine months of 1916 was 1.77 per cent. for each period. It is doubtful if this plant could make 80 per cent. of this amount of steel without the use of roll scale. The practice of using roll scale was started at this plant in December, 1906, prior to which the silicon in blast-furnace metal averaged 1.36 per cent. for 1905 and 1.37 per cent. for 1906. The period from June 15 to July 15, 1916, shows an average of 1.90 per cent. silicon in blast-furnace metal, the lowest cast being 1.03 per cent. and the highest, 2.98 per cent. In Table III. under column heading "Time of blow" will be found some data obtained on heats blown at the same time and under the same conditions that illustrate the influence of roll scale on time of blow.

To analyse the comparative cost of the practice we have been discussing is naturally a very complicated matter. Some Bessemer superintendents claim that it takes 2 tons of roll scale to make a ton of steel. This estimate seems to us excessively high, but even if such were the case we have in this practice a direct method of producing steel far below the cost of any known process.

In order to determine the influence of roll scale by itself, we made several experiments in November, 1916, by running five heats with and without scale at the same time in this plant, all other conditions being maintained constant as nearly as possible. The results of these tests are given in Table III. The difference in time of blow is the most striking feature. This is entirely accounted for in the shortening of the silicon blow. For example, we give the following records from heats which were carefully watched in this respect, from the last series in Table III.

Without roll scale.			With roll scale.		
Heat No.	To first carbon flame. Minutes.	Finish of blow. Minutes.	Heat No.	To first carbon flame. Minutes.	Finish of blow. Minutes.
3	7	14½	3	2½	10
4	7½	15	4	3½	11
5	7½	15	5	3	10½

The quicker removal of silicon is apparently due to the large excess of oxygen supplied by the roll scale, and to the oxide of iron which remains in the bath available for combination with the silica. Silica is thus removed from the bath as fast as it forms, and we have a good slag from the time the vessel is turned up. The rapid reduction of the magnetic oxide is clearly indicated by the chilling effect on the heat, which is equal to about one and one-half times that produced by the same weight of pig-iron.

To determine whether a larger percentage of iron was carried away in the slags under certain conditions, samples of mixer metal and slag were taken for analysis throughout the month of November, 1916. They indicated that these slags are fairly uniform. At least, the combined iron in the slags does not vary with the silicon in the charge, as would be expected if the variable amount of roll scale added had any material influence on the slag. As the converter slags were as a rule observed to have the same physical consistency as well as practically the same analyses under this practice, it may be assumed that the free iron or shot carried away in the converter slag is also proportional to the weight of slag produced, which varies with the silicon in the charge.

During the month of November, 1916, we weighed all the converter slag that was sent away from the mill, and weighed or estimated the loss in the lining and bottoms of the converters. With these data and the analyses of the slags and the charge throughout the month, we have computed the loss in metal in the slag as follows:—

Converter Slags.

Weight of slag calculated from silica contents per charge of 22,400 lbs.:

	SiO_2, Lbs.
100 lbs. from bottom × 80 per cent.	= 80.0
50 lbs. from sides* × 97 per cent.	= 48.5
	128.5
1.74 per cent. Si in charge = 0.0174 × 22,400 × 60/28	= 835 2
Total SiO_2 in charge	= 963.7

Slags carry 60 per cent. SiO_2 (averaged from analyses of samples after removing shot).

Silicates in slag = $\frac{963.7}{0.60}$ = 1,606 lbs.

Slag per heat, as weighed for month = 2,016 lbs. (= 9% of charge).

Theoretical weight of slag from SiO_2 in silicates = 1,606 lbs.

Shot and scrap = 410 lbs. or 20.3% of slag.

Combined iron in silicates = 16 per cent. × 1,606 = 256 lbs. = 12.7 % of slag.

Total iron in slag = 33.0 %

* Estimated by measuring vessel before and after 500 heats.

The silicon in the charge for the group of heats included in the test heats referred to in Table III. was practically the same as the average for the entire month. The actual converter and cupola loss for this month amounts to 9.05 per cent., which is somewhat above the average, due to an unusually high percentage of shot in the slag and to the fact that the average silicon for this month was comparatively high. The converter and cupola losses for this month have been analysed as shown in Table I.

TABLE I.—*Converter and Cupola Losses—National Works, Month of November*, 1916.

Loss in direct iron.	Per cent.	Loss in cupola iron.	Per cent.
Carbon	4.11	Carbon	3.90
Silicon	1.89	Silicon	1.66
Manganese	0.70	Manganese	0.60
		Cupola loss	1.24
	6.70		7.40

Known losses of other materials.

	Per cent.
Steel scrap	0.25
Ferro-manganese	30.00
Roll scale	(?)
Per cent. vessel and ladle slag	9.00
Total iron in slag	33.00*

* This is about 10 per cent. higher than the yearly average for 1915 due to stiffer vessel slag and greater amount of shot include d

Material charged.	Per cent. of charge.	Per cent. loss.	Per cent. of total charge lost.
Direct metal	76.58	6.70	5.13
Cupola metal	10.76	7.40	0.80
Steel scrap in vessels	4.27	0.35	0.01
Ferro-manganese and ferro-silicon	0.57	30.00	0.17
Roll scale	3.93	—	(?)
Pig-iron (for scrapping in vessel)	3.89	6.70	0.26
Iron in slag (9.0 per cent. × 33.00)	—	—	2.97
			9.34
Less credit received for iron in slag returned to blast furnaces for month	—	—	0.15
Theoretical loss	—	—	9.09
Actual loss	—	—	9.05

For comparison we give, in Table II., the converter and cupola losses at this plant for 1915, which are more representative of the average practice.

TABLE II.—*Theoretical and Actual Losses for* 1915 *—National Works.*

Loss in direct iron.

	Per cent
Carbon	4.25
Silicon	1.76
Manganese	0.70
Total	6.71

Loss in cupola iron.

	Per cent
Carbon	4.00
Silicon	1.56
Manganese	0.60
Cupola loss ..	1.26
	7.42

Loss of other materials added.

	Per cent.		Per cent.
Loss in steel scrap (Mn)	0.35	Per cent. vessel and ladle slag	8.20*
Loss in ferro-manganese	30.00	Iron in slag	23.40
Loss in roll scale ..	—		

Material charged.	Per cent. of charge.	Per cent. loss.	Per cent. of total loss.
Direct metal	77.15	6.71	5 17
Cupola metal	11 49	7.42	0.85
Steel scrap used in vessels ..	3.57	0.35	0.01
Ferro-manganese and ferro-silicon	0.59	30.00	0.18
Roll scale (metallic)	2.89	—	(?)
Pig-iron used for scrapping vessel	4.40	6.71	0.30
Plus iron in slag (8.2 per cent. × 23.40 per cent.)	—	—	1.92
			8.43
Less credit received for iron in slag	—	—	0.09
Theoretical loss	—	—	8.34
Actual loss	—	—	8.15

* Estimated.

The use of roll scale was started at the National Works in December, 1906. For that year the silicon in the charge averaged 1.29 per cent. Assuming all other conditions to be unchanged, the increase in converter loss due to raising the silicon in the charge to 1.61 per cent., as was the case in 1915, would be about 0.3 per cent., based on the slag carrying 24 per cent. iron in each case.

There is probably a little more loss due to the greater activity of the reactions in the converter when using dirty or moist roll scale, but this is recovered for the most part and is credited to the steel works. The free iron now lost in the converter slag might also be recovered to advantage so that the necessary excess loss by this practice would consist of only a little more than the combined iron in the larger volume of slag due to a higher content of silicon. As the per cent. of combined iron in the slag has been found to be practically constant, this would be lost in any case in proportion as the silicon in the charge is raised, which we maintain is warranted to a certain extent on the basis of better quality alone.

Against this loss, most of which is in consequence of the larger volume of slag produced, we must credit a 20 per cent. reduction on steam cost and a similar reduction in most of the other items of cost, together with a 10 per cent. increase in scrap-melting capacity due to the use of higher-silicon iron. It is hardly necessary to produce further figures, even if we had them, to indicate that there is a substantial saving in cost of production by this practice. It may be said that it costs a little more to make the higher-silicon iron, but this is obviously more than offset by the advantages obtained, some of which, such as increased yield of finished product, are difficult to compute.

We have attempted to give briefly the results of 10 years' experience in the use of roll scale under the conditions that prevail at this particular plant. However, in summing up the benefits derived, as "better steel," "increased production" and "lower cost," we would not have the reader conclude that this is a "cure-all," as the practical Bessemer operator will readily appreciate that there are many other details such as temperature, ladle reactions, etc., which will require just as much attention as ever. Aside from other factors, however, the judicious use of roll scale is a study within itself.

TABLE III.

Exper. run No.	Analysis of mixer iron.			Weight of charge in lbs.					Per cent. Si in charge.	Blast press. Lbs. per sq. in.	Time of blow. Min.	Analyses of slags.					
												Converter slag.			Ladle slag.		
	Total C.	Si.	Mn.	Mixer iron.	Pig-iron.	Steel.	Roll scale.	Total weight.				SiO_2.	Iron.	Mn.	SiO_2.	Iron.	Mn.
No. 1.																	
Without scale.	4.34	1.96	0.84	18,640	—	3,160	—	21,800	1.80	23	10.0	65.27	15.30	8.11	53.12	15.70	14.00
With scale ..	4.21	2.20	0.81	19,180	—	2,130	1,210	22,520	1.90	23	12.5	61.80	17.50	7.84	50.10	16.20	13.44
No. 2.																	
Without scale.	3.98	1.60	0.76	19,000	3,000	—	—	22,000	1.63	25	18.6	63.60	16.20	8.11	48.06	15.60	12.84
With scale ..	4.06	1.63	0.77	19,000	2,000	—	1,000	22,000	1.56	25	10.0	62.26	17.70	8.64	48.64	16.50	12.97
No. 3.																	
Without scale.	3.92	1.62	0.70	19,100	3,500	—	—	22,600	1.62	25	18.9	65.34	16 50	8.24	50.48	13.00	11.59
With scale ..	4.00	1.96	0.75	19,200	2,500	—	1,400	23,100	1.87	25	11.3	63.40	16.50	8.15	52.04	15.90	12.94
No. 4.																	
Without scale.	4.24	1.79	0.64	19,020	2,540	—	—	21,560	1.80	25	15.0	63.50	14.50	6.82	47.40	18.20	18.21
With scale ..	4.00	1.77	0.68	19,080	1,550	—	1,000	21,630	1.69	25	10.2	60.50	18.70	8.01	47.00	16.10	16.95
Averages ..	4 .08	1.82	0.74						1.73								

NOTE.—The average weight of all converter slags produced for this month was 2,010 lbs. per heat. The ladle slag averaged 417 lbs. per heat and was quite constant.

Refractories for Steel Furnaces.

At a recent ordinary meeting of the Refractory Materials Section of the Ceramic Society, held at Stourbridge, Major H. C. King presiding, Mr. W. J. Brooke (Shelton Iron, Steel and Coal Company, Limited) read a Paper on "Refractories for Steel Furnaces from the Consumers' Point of View." He referred to the pressing need for careful investigation and research into the various problems underlying the principle and method of manufacture of refractories for open-hearth work at the present time. Hitherto, he said, it had been largely a matter of depending on natural resources of proved worth and the manufacturers' rule-of-thumb experience. Silica bricks from certain localities only had been considered suitable for the post of danger in a furnace; others from a different source were only entrusted with a lesser degree of responsibility, whilst those from a third source could be relegated to the holding of lines of communication between inferior positions and the more advanced points.

When trouble arose, the furnace manager, bewildered by paper figures (analysis, etc.) could only point to his furnace facts, and usually came to the conclusion that analysis was no good. To a certain extent, he was right, but the scientist never explained to him why. Practically every grade of silica brick to-day was inferior to what it was three years ago, though the analysis was very little different from what it was in pre-war times. Looking ahead one saw that in order to cut down the cost of repairs to a minimum, so as to meet keener competition when it came, and, coupled with the increased demand and the limited natural supply, it would be necessary for science to step in so that materials suggesting themselves as good from their chemical composition might be properly harnessed and made to yield the full percentage of their possible qualities. Upon the intelligent furnace manager many questions must have been pressed by the very erratic behaviour of silica bricks, not only of those from different makers, but those of the same producer. Sometimes these bricks gave excessive expansion, with the result that walls or blocks or roofs broke up from the excess lateral crushing stresses. Others "ran" with the least provocation, whilst at times he was troubled by a mysterious softening and breaking away of portions of the bricks in lumps of various sizes and without any appearance of true fusion. At other times the bricks in a roof or crown commenced to spall when gas was first put in, notwithstanding the fact that the brickwork had been thoroughly dried, and anxiety was experienced whilst calculating whether the total disintegration of the bricks or the inversion of the silica would first occur. In such cases consultations with the makers had rarely been of any use.

Excessive expansion, continued the author, is almost certainly due to defects in manufacture, generally traceable to the bricks not having been thoroughly dried before burning, or insufficient burning, or both. The remedy is obvious. The "running" or complete fusion of the bricks, evidenced on the walls and blocks of a furnace as a very pronounced "smear," and in the roof or crown as "icicles," is the cause of friction between furnace men and managers, the former blaming the brick, and the latter carelessness in the manipulation of the furnace. The latter, undoubtedly, occurs, and the remedy is clear; but the former also occurs, and the remedy is not so obvious. It may be associated with comparatively low percentage of silica in the bricks, but usually also with excess of lime used as bond.

The softening and breaking away in lumps often shown, notably in a roof, is probably one of the most serious of all the furnace troubles. In a particularly bad case of this kind in the roof of a large furnace, no adverse conditions were noticed until the temperature of the furnace was raised to the casting point of the charge. The roof bricks were then observed to apparently soften, particles of various sizes detaching themselves and breaking away. There was no apparent "running" of the material and no "spalling"; just a kind of glutinous softening and a quiet disintegration of very considerable portions of the bricks. This continued for some time, and the furnace had eventually to be put off for repairs after about two weeks' working. Analysis of samples of the remaining brickwork gave 96.2 silica, 0.31 alumina, 0.49 ferric oxide, 2.13 lime, a trace of magnesia, and 0.15 alkalies. The texture of the bricks was very coarse, with an admixture of a very finely ground body as a bond. The bricks were actually made from a very pure quartzite containing about 98 to 99 per cent. silica. Prolonged investigation elicited the fact that the makers in an emergency had to use in place of their usual ganister (which required the minimum of foreign admixture to produce a good brick), another material which in its natural state was much more refractory. To make a "strong" mechanical brick with this material a certain amount of lime was added. Following on their ordinary practice, which had shown that a large percentage of coarse particles gave good results, the material was ground as usual, lime wash being added in the correct proportion to give the usual chemical analysis. Owing to the highly refractory main body of the brick being coarsely ground, the binding material was dispersed throughout the mass in proportions out of balance to the general average constitution, and the final result was that the bond, being more fusible than the general structure, melted and carried away with it the more refractory bulk, which was thus rendered useless.

"Spalling" is probably always due to the bricks not having been properly burned. The material may be coarse or fine in texture, the analysis perfect from the accepted point of view, and everything apparently good. But since complete inversion has not been brought about, spalling is caused, and in a similar though reverse manner to the spalling of magnesite bricks as described by Dr. Mellor. The remedy is again obvious.

The author proceeded to refer to Professor Arnold's recent mention of the fact that the steel-making furnace at Sheffield University is available for testing bricks, adding that, in his opinion, there is, without interfering with Professor Arnold's valuable work, plenty of scope for investigations to be carried out in other centres. There are hundreds of brick-testing furnaces in this country, he continued, using such materials every day. It may be said that furnace managers are too busy to bother about testing other people's products, yet if it is seen that an improved product will be the

result, the importance of the object will secure their ready co-operation. What is wanted is the collaboration of the maker, the consumer and the scientist. The author suggests that all the steel manufacturers and refractory brick makers in the country should become members of the Ceramic Society, and contribute further to a research fund. Tests of raw material or manufacture should be carried out at such steel works with modern furnaces as might offer to place their plant at the disposal of the Society for the purpose, such tests to be carried out under the supervision of representatives of all three interests. The tests could be graduated, and the previously untried material tested under conditions suggested by the growing confidence in its capabilities (or otherwise). Makers could, under the proposed scheme, submit samples to the scientist, who would, in the first instance, pass a verdict as to the bare possibility of the material being successful. The preliminary diagnosis would also afford some information as to the degree of responsibility to which the material might be trusted. The graduated furnace tests could then be applied, until the limit of its specific refractoriness was reached. Varying degrees of texture, density and porosity, chemical constitution, thermal treatment, variations of bond, etc., might be tested. The results would, in the first instance, only be communicated to the individual brickmaker, or according to arrangement. They would, however, be very valuable to maker and user, and ultimately to the country as a whole.

The author suggests that the best guide in the case of the highest grade of silica brick is its behaviour in the roof of a large steel furnace, in which the length, between "blocks" is over 30 ft., the most severe testing conditions existing between crown and skewback over the tap-hole for a distance varying from 2 to 5 ft. on either side of the transverse centre line of the furnace. Here all the various defects previously enumerated can be observed, so that if bricks found satisfactory in other parts of the furnace prove their worth also in this position, they are of the highest quality possible.

As pointed out by Mr. Cosmo Johns, at the recent meeting of the Iron and Steel Institute, one of the most important points to be investigated is abrasion at high temperatures by the furnace gases. It is almost certain that abrasion in the gas ports is due to the velocity of the moving column of gases which at the outgoing block has to divide into several smaller columns, less in area and some areas smaller than others. Abrasion can generally be noticed at all points where the moving column or columns receive a check or are made to take a different direction. In such cases the effect of abrasion is shown by smooth, round corners or by hollows neatly scooped out, and one can see small evidences of actual fusion. It is probable that the gas molecules in the moving column are swept on as "eddies" and "swirls," and that being at an elevated temperature, their kinetic energy also plays a considerable part. C. Canaris, in "Stahl und Eisen," some years back, advanced a somewhat similar reason for the greater destruction of brickwork consequent on the employment of producer gas, high in hydrogen, or water vapour, or both. This may, to a certain extent, be true, for since the dissociation point of water, vapour is lower than the average flame temperature in an open-hearth furnace, hydrogen from whatever source will combine with oxygen in the cooler parts —the backs of the outgoing block and regenerator uptakes. There may thus be a kind of surface combustion, which aids the abrasive action of the velocity of the gas particles by previously softening the refractory material. Here is a wide field for research whereby different materials variously compounded may be tested for resistance to abrasion. Probably composition, texture, bond, will all have to be examined to achieve success.

The silica bricks supplied by the average maker were rather severely criticised, it being stated that 3-in. squares may vary in a consignment between ¼ in. under and ¼ in. over, the corners being absent, the surface very rough, and the bricks not square. Complaints to the senders elicit the information that the use of their cement will put the matter right. But the cement has not been subjected to the same heat treatment as the brick, even if the composition should be the same. To make such bricks lie true requires a good bedding of cement, which cement has to be ground up with water to a thin consistency. Joints in places easily up to ¼ in. or ½ in. are common, and that means that at least 15 per cent. of the structure is cement. This has to be converted into brickwork by drying (which makes the material very porous), and by burning (to invert the silica). Assuming that the bricks are well burned and of good composition, 15 per cent. of the whole structure has to undergo alteration in volume. If the composition of the cement is not as good as that of the brick the case is aggravated, and the life of the furnace becomes seriously shortened.

Magnesite bricks are usually employed in the bottom of the furnace underneath the basic material. The chief essentials of a good magnesite brick are perfect shape and size, fineness of texture, practically absence of porosity, intense hardness, maximum density, and freedom from any tendency to hydrate or "fall." The Styrian bricks made by Carl Spaeter and other Austrian makers fulfil all these requirements. Unfortunately the bricks made by English makers fall very much short of the stipulated requirements. The author recalled that the foreign bricks were fine textured, hard pressed, very heavy, and when broken showed a small crystalline semi-vitreous fracture, and the bricks when struck rang like a piece of metal. On one occasion in a pressing emergency a few bricks were got from a merchant's stock, which instead of being 9 in. by 4½ in. by 2½ in. were about 8½ in. by 4½ in. by 2⅜ in. These were of a pale lemon colour, very square and smooth, gave a ring like a bell, and were excessively hard. There was merely a trace of iron oxide and alumina, and very little lime, but the actual analysis has not been preserved, though they must have been made of a very pure magnesite. They proved exceedingly good in use—at least as good as Spaeter's bricks. He was informed that they were a spoiled lot, and owing to a mistake had been "burned" and had turned out undersized. He had been unable to find out who had made that "mistake."

At least seventeen years ago Carl Spaeter referred to the necessity of high temperatures in making his bricks. He even remarked that the special furnaces used for burning them had to be made of magnesite bricks. These plain hints had never been acted on in this country. There was no doubt that Spaeter bricks owed their value to fine grinding, high preliminary burning, powerful hydraulic pressure in making, and high temperature in burning the final product, this last being the most important.

D

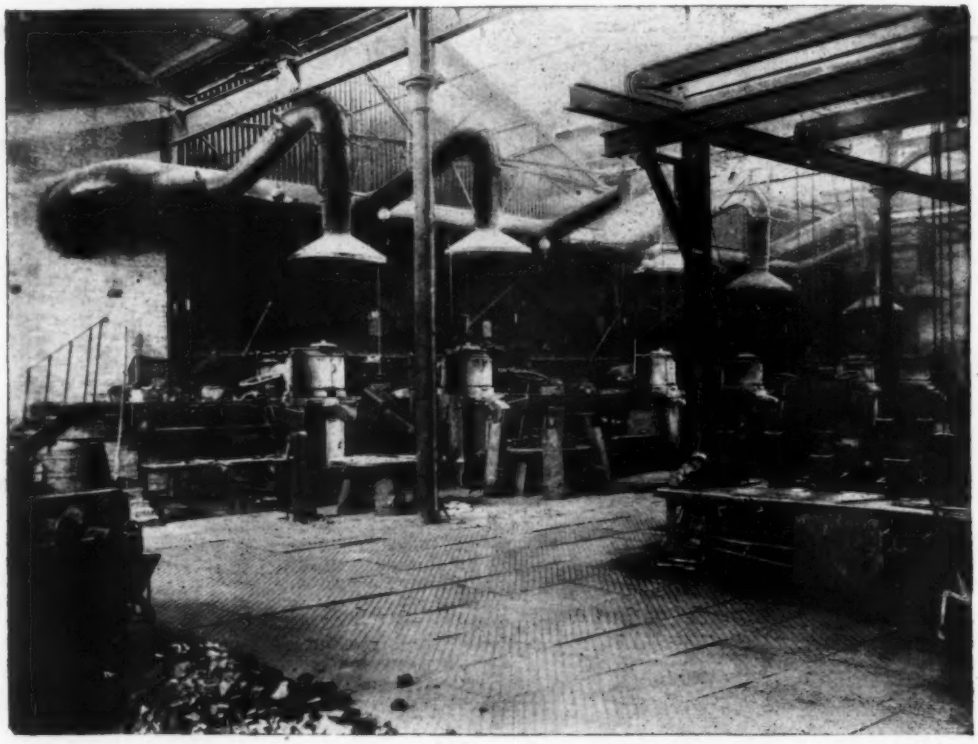
Wright-Morgan Furnaces.

The Morgan Crucible Company, Limited, announce that they have entered into an agreement with Messrs. John Wright & Company (John Wright and Eagle Range, Limited), of Essex Works, Birmingham, whereby the interests of the two companies in regard to crucible-furnace manufacture and supply will be mutual. Well-known types of patent tilting furnaces and "lift out" furnaces have been made by the Morgan Crucible Company, Limited, for the past ten or fifteen years for melting all crucible metals, with almost every available useful fuel, and have been installed in the leading national factories, arsenals, dockyards, railways, on board repair ships, and in use by most of the large engineering companies, founders, and refiners in this country and abroad. These furnaces will be manufactured in future for the Morgan Crucible Company by Messrs. John Wright & Company.

It is intended that the best types and patterns of both companies be supplied, and these, together with all new joint designs, will be known as "Wright-Morgan" furnaces. In making this arrangement the Morgan Crucible Company have in mind the best interests of furnace and crucible users, and its technical experts will still be constantly employed upon improvements in melting systems and the design of crucible furnaces with the assistance of the staff of Messrs. John Wright & Company.

The Morgan Crucible Company has always been able to design its furnaces in conjunction with the manufacture of special crucibles for use therein, so that maximum efficiency of melting and life of crucibles have been obtained. The company therefore contends that had it not been for the pioneer work it carried out on the development of this class of melting plant over a period of many years previous to the outbreak of war, it would not have been able, in August, 1914, to recommend, with every confidence in complete success, its direct method of casting munitions metals. Several systems of direct casting from crucible tilting furnaces, we understand, have now been based upon the Morgan Crucible Company's practice, and a rapid and economical method of producing brass strip, rod and billets, for carriage cases and fuses, has resulted. The first installation of a battery of tilting furnaces and casting turntables ever used in this country for brass-strip work is shown herewith. Upwards of 3,000 tons of brass per week have been regularly cast in the manner shown from the Morgan's patent tilting furnace plants supplied and erected since the outbreak of war.

By entering into this agreement with Messrs. John Wright & Company for the manufacture of melting furnaces the construction of the latter will be concentrated in Birmingham under skilled supervision, the best materials and workmanship will be employed, execution of orders will be accelerated, and the Morgan Crucible Company will be free to absorb the valuable space hitherto occupied for furnace work into its crucible-making



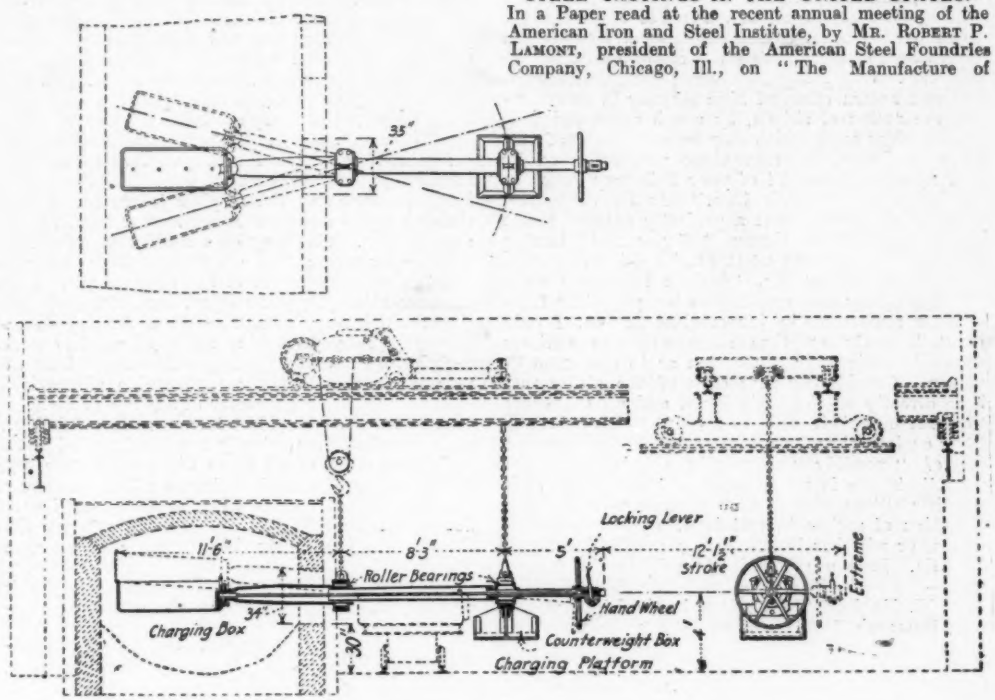
INSTALLATION OF TILTING FURNACES AND CASTING TURNTABLES FOR BRASS STRIP WORK.

departments, which will also react to the advantage of crucible users.

It is perhaps unnecessary to add that the production of crucibles by the Morgan Crucible Company, for use in all types of furnaces, will in no way be affected or restricted by reason of this arrangement.

Furnace Charging Machine.

The new type of single-hoist charging machine for open-hearth or electric furnaces illustrated herewith has been designed as a substitute for, or an auxiliary to, electric charging machines. According to particulars given in "The Iron Age," only four men are required for its operation. Its movements are directed from the hoist of an overhead travelling crane. The front bearing is hung on the crane hook, while the rear one is suspended at a fixed height above the floor by a chain attached to a small roller-bearing trolley running on the bottom flanges of a girder attached to the crane trolley. The small trolley permits the charging bar to be swung on the ball bearing of the hook block as shown herewith. The machine is carried on two cast-steel collars containing large roller bearings, on which the charging bar rotates by means of a large-diameter cast-steel handwheel. The locking rod for fastening the charging box to the charging bar passes through the centre of the machine, and is operated by the lever adjacent to the handwheel. The counterweight box is designed to be filled with punchings to balance the charging box and its load. In operation the crane lowers the charging bar to engage the charging box, which is locked to the bar by the manipulation of the locking rod lever. The bar is then hoisted and run forward to place the box in the furnace, where it is dumped by turning the handwheel. The movement of the wheel is continued until the box is righted, when it is withdrawn from the furnace and placed on the charging platform. A backward motion of the locking-bar lever releases the box, which is replaced by another one, and the cycle repeated.



SINGLE-HOIST CHARGING MACHINE FOR OPEN-HEARTH OR ELECTRIC FURNACES.

THE death is reported of Mr. J. H. Greene, of Liverpool, at the age of 63 years. The deceased was the secretary of John Birch & Company, Limited, machinery and metal merchants, 2, London Wall Buildings, London, E.C., with whom he had been attached for over 25 years.

STEEL CASTINGS IN THE UNITED STATES.—In a Paper read at the recent annual meeting of the American Iron and Steel Institute, by MR. ROBERT P. LAMONT, president of the American Steel Foundries Company, Chicago, Ill., on "The Manufacture of Steel Castings," it was stated that of the approximately two million tons capacity of steel castings in the U.S. to-day about 52 per cent. is for basic and 48 per cent. acid steel. Almost 90 per cent. is produced in open-hearth furnaces, 8 per cent. the converter, and the balance crucible and electric. There are no accurate figures showing a division of tonnage as between dry and green sand moulds, but the figures are probably not far from 60 per cent. green sand and 40 per cent. dry sand. To-day there are about two hundred steel foundries in the U.S., with a total rated capacity of approximately 2,000,000 tons, though the actual production given for last year was probably about 1,500,000 tons. The electric furnace will in time entirely replace crucibles and converters as a means of melting.

Correspondence.

Effect of Silicon on Cast Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Mr. Adamson appears to recognise no difference between the terms "absolute control" and "conditional or contingent control." To say flatly as he did (see page 73 of your February issue) "silicon content does not *control* combined carbon and its ratio to graphite" is quite incorrect without making certain qualifications. I have attempted to discuss those qualifications in my two previous communications. To say, as Mr. Adamson does in his last letter, that I have *now* admitted that silicon does not so control is absurd. If he will refer to my first communication (p. 194) he may note that I even then said that the effect of silicon may be sometimes nil, i.e., if its effect is overruled by other factors.

I have already dealt with some of those other factors, and the effect they may exercise. The list was by no means complete, but was only intended to show what other causes might modify the action of silicon in precipitating the combined carbon as graphite. One thing I have not yet mentioned is the well-known effect of high sulphur in neutralising the action of silicon, by which effect one may obtain white irons which may be nevertheless fairly high in silicon. One of these was described by Mr. Adamson (page 74 of your February issue) as "admittedly a freak iron." It is, of course, nothing of the sort, but a perfectly natural result of the high sulphur shown (0.27 per cent.) having nullified the opposite effect of the silicon.

As regards what Mr. Adamson terms my *error* in drawing my own conclusions (on page 193) from a later statement in his original article, I only pointed out that that statement was entirely opposed to his main contention as to the effect of silicon. Considering that each of the statements bore directly on the main issue, and all I did was to point out their mutual incompatibility, it is a little curious that Mr. Adamson should now accuse me of "possibly unwittingly side-tracking the issue." There is no question of the issue. It is whether silicon exercises no control over the distribution of carbon in cast iron, as Mr. Adamson states, or whether it exercises a qualified control, as I do. It is worth while to subjoin the following:—

W. H. Hatfield ("Cast Iron in the Light of Recent Research," 1912 ed., p. 41): "The influence of silicon is always conditional, and is exerted indirectly by its influence on the condition of the carbon . . . nevertheless, the author would be the last person to detract from the practical utility of the control of this element [silicon] in works practice."

J. E. Hurst (Paper on "Semi-Steel," Proc. B.F.A., 1915-6, p. 232): "The proportion of that element [graphite] was to a certain extent controlled by the silicon content."

One could quote hundreds of such opinions but there is no need. Mr. Adamson constantly makes vague general statements. An example of this occurs in his last letter, and reads as follows:—"Manufacturing conditions . . . control those analyses which are capable of variations in smelting operations." On considering this statement I have come to the conclusion that if you cut out all after the word "analyses" as being redundant, the statement is true in a limited degree. *All* pig-iron compositions (or analyses, as Mr. Adamson will have it) are capable of variations due to smelting operations, and this part of the statement is therefore unnecessary. We are thus reduced to the simpler form "Manufacturing conditions control compositions of pig-iron." Well, to a certain extent, they do. The average chemist or metallurgist, even if without blast-furnace training, by no means underestimates the complexity of factors which exist in a blast furnace during the smelting of pig-iron, and is quite aware that it is by variation in the conditions of running, variations in the character of the ores and fuels charged, whether hot or cold or high or low-pressure blast, different temperatures obtaining in boshes and hearth, time occupied from charging in to tapping out and so forth, that such varying qualities of irons may be obtained. In one sense it is a truism to say that manufacturing conditions control compositions. You may, for example, have a blast furnace running under such conditions as to produce white-iron. It is perfectly correct to say that the furnace conditions are controlling the carbon distribution, and the other characteristics of the resulting pig. If, however, you now take that white iron and anneal it under suitable conditions, you can almost entirely convert the combined carbon into graphite. In other words, you have quite neutralised the primary controlling influence of the blast furnace towards producing combined carbon.

Again, if you melt a soft grey iron in a cupola it usually becomes harder, owing to the silicon being reduced and the sulphur increased. Put it through again and it becomes harder still, for the same reason. This is quite a well-known effect. It is simply another factor which modifies the composition and properties of the original pig. I am not now attempting to suggest that remelted irons (irons which have been through a cupola) do not generally largely retain their original characteristics. I am merely suggesting that there are modifications, sometimes profound modifications, which occur in the character of an iron after it has been produced by a blast-furnace. Mr. Adamson, as a practical man, simply *must* acknowledge the modifying effect of all these different factors. In reality he does, but he is so down on his *bête noire* of "silicon control" that, when it suits him, he will not admit anything which seems to suggest that silicon has any governing power, influence, or effect on the carbon distribution in cast-iron. I should like, however, in this connection to ask him precisely what he means by the following statements:—

"Silicon and combined carbon, he would say, were certainly somewhat related, but only in a general way." (Paper on "Carbon—Temperature—Iron," Proc. B.F.A., 1915-16, p. 214.)

"It is an undoubted fact that, taking a given iron *under exactly the same conditions* of melting, pouring and cooling, the higher the silicon the softer the iron within limits, and these limits apply in general principles to all the fractures of pig-iron between white and mottled on the one hand, and 'glazy' pig on the other." ("F.T.J.," February issue, p. 76.)

It is to be noted that Mr. Adamson declines to enter into what he describes as "an academic discussion on the modifying influences of chemical composition, when x, y and z conditions are constant, as is only possible in laboratory experiments." It ought, however, to be obvious to any practical man that to ascertain the true effect of any one factor in cast-iron you must as far as possible fix all the others and vary that one.

Finally, I think that the different considerations affecting the issue of this discussion could hardly have been better put than in the editorial comments on page 72 of your February issue, "Heredity and Pig-iron." Mr. Adamson should re-read this before writing further on the matter.

Yours etc.,

Bedford, July 16, 1917. R. T. ROLFE.

Oil-Fired Furnaces in the Foundry.

To the Editor of THE FOUNDRY TRADES JOURNAL.

SIR,—With reference to the paper by Mr. H. G. Barrett entitled, "Notes from the Brassfoundry," read before the London Branch of the British Foundrymen's Association (see June issue), we notice that the oil-fired furnace comes in for considerable criticism. Possibly Mr. Barrett has had no experience of the Monometer oil-fired furnace, which we have supplied in large numbers not only for melting the non-ferrous metals, but also to the Sheffield steel trade for the melting of high-speed steel. In this furnace is employed below the crucible a combustion chamber in which the initial combustion takes place; the flame obtained is then non-oxidising and incandescent, whereby long life of the crucibles and linings is obtained. Users have stated that they average 66 melts from each crucible; this is not from a specially conducted experiment at the makers' works, but a result obtained by users in everyday work. The burners are designed to use any fuel oil available, with perfect combustion and without smoke.

Regarding Mr. Stone's remarks about the starting up of the furnace, we have never found any difficulty, and we get a clear flame inside a minute from the turning on of the oil, without smoke or soot. Another advantage of the Monometer oil burner is that non-ferrous metals are melted with only 1 lb. air pressure, steel and the like requiring a slightly higher pressure, say of 4 lbs. per sq. in. We should be very pleased to show the Monometer oil-fired furnaces in operation. There are large batteries of these furnaces working in different parts of the country, using all grades of fuel oil, which we think effectually rebuts Mr. Barrett's statement that the oil furnace is still in its infancy.

Yours, etc.,

MONOMETER MANUFACTURING CO., LTD.

Whitehouse Street, Aston, Birmingham.

Munition Workers' Health.

Official Report.

At the instance of the Government Committee on the Health of Munition Workers, Dr. H. M. Vernon has continued his investigations into the influence of work hours on output, and the results of his further inquiries have now been made public in a Parliamentary Paper. The Committee express the opinion that the data at their disposal are not yet ample enough to permit them to arrive at a final judgment upon the whole question of hours of labour in relation to output, on the one hand, and the well-being of the employee, on the other. But they are strongly of opinion that the evidence collected by Dr. Vernon, and the conclusions he deduces therefrom, merit the immediate and earnest consideration of all concerned in industrial organisation at the present time. At the close of a long and detailed statement Dr. Vernon summarises it as follows:—

(1) Observations extending over a period of 13½ months upon the output of workers employed in making fuses showed that a reduction of working hours was associated with an increase of production both relative and absolute. The rate of production changed gradually, and did not reach an equilibrium value before the expiration of four months. Thereafter it remained steady during the period of 3½-5 months during which it was observed. The *gradual* change negatives the suggestion that the effect was a mere consequence of the desire to earn the same weekly wage as before the hours were shortened.

(2) Owing to the reduction of the working time, first by a change from a 12-hour day to a 10-hour day, and subsequently by the abolition of Sunday labour, it was possible to compare output under three conditions. The group of women (numbering from 80 to 100) engaged in the moderately heavy labour of turning aluminium fuse bodies provided the following comparative results:—(i) When actually working 66.2 hours a week and nominally 74.8 hours their relative hourly production was 100 and their relative gross production 100; (ii) When actually working 54.8 hours and nominally working from 58.5 to 66 hours their hourly production was 134, and their gross production 111; (iii) When actually working 45.6 hours and nominally working from 49.5 to 58.5 hours their hourly production was 158 and their gross production 109. It is therefore to be inferred that had these women been working uniformly a nominal 50-hour week their gross output would have been as large as when they were working a nominal 66-hour week, and considerably greater than when they were working a 77-hour week. In other words, a considerable addition to the leisure time of the operatives would have substantially improved the total output of the factory.

(3) A group of 40 women engaged in the light labour of milling a screw thread on the fuse bodies improved their gross output by 2 per cent. when actually working 54.8 hours a week, the standard being their gross output when working 64.9 hours per week. A further reduction of actual working hours to 48.1 resulted in such an improvement of hourly output that the gross output was only 1 per cent. less than when the actual working time was 16.8 hours more.

(4) A group of 56 men engaged in the heavy labour of sizing the fuse bodies improved their hourly output by 37 per cent. and their gross output by 21 per cent. when actually working 51.2 hours, the standards being the hourly and gross outputs observed when their actual weekly hours were 58.2.

(5) Fifteen youths engaged in the light labour of boring top caps by means of automatic machines produced only 3 per cent. less output when their actual weekly hours of work were 54.5 hours than when they were 72.5 hours.

(6) In none of the operations studied was there any change either in the nature of the operation or of the type of machinery during the period under notice. The data were also so chosen as to eliminate any possible disturbances due to increasing skill.

(7) A part of the improvement in output was due to the workers starting work more promptly when on shorter hours. At one period the women engaged in turning fuse bodies lost on the average 37 minutes daily by starting work after, and stopping before, the nominal time. Nine months later, when their hourly output was 25 per cent. better, they lost only 26.5 minutes daily in these ways.

(8) A rest from work on Sunday is followed by a relatively low output on Monday, and this output steadily rises in the course of the week, owing to the increased efficiency produced by practice. Generally, the cumulative effects of fatigue neutralise and overpower this increase efficiency, and the output may fall after the second day (or night) of the working week if the hours are long and the work laborious, or not till after the third, fourth, or even fifth day, if the hours are shorter. In the absence of a Sunday rest the fatigued worker has no opportunity for complete recuperation, and his output, though more uniform, remains permanently at a lower level than that shown on Monday by a worker who has rested on Sunday.

Trade Talk.

VERITYS, LIMITED, have removed their Birmingham business to Phœnix Chambers, Colmore Row.

THE engineering business of E. H. Shorland & Brother, Limited, Failsworth, Manchester, is being offered for sale as a going concern.

A WINDING-UP order has been made in connection with Steel's Electric & Engineering Company, Limited, 206, East India Dock Road, Poplar, London, E.

MR. W. J. HARPER, the London agent of Messrs. Ansell, Jones & Co., ironfounders, Birmingham, has removed to 36, Camomile Street, London, E.C.3.

RUSTON, PROCTOR & COMPANY, LIMITED, of Lincoln, have moved their London office from 46, Queen Victoria Street, E.C., to West Africa House, Kingsway, W.C.2.

THE INTERNATIONAL TOOL COMPANY, LIMITED, is being wound up voluntarily, with Mr. J. Baker, Eldon Street House, Eldon Street, London, E.C., as liquidator.

A LIVERPOOL firm have purchased the property and plant of the Whitstable Shipping Company, and propose to convert the undertaking into a shipbuilding establishment.

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY, LIMITED, propose acquiring some disused tramcar sheds at Nether Edge, Sheffield, for the purpose of extending their business.

THE Minister of Munitions desires that the customary holidays at the customary date and for the customary period should be observed in each locality by establishments engaged on munitions work.

NEGOTIATIONS are understood to be in progress on the Wear for the establishment of a new shipyard. The site was many years ago in use for shipbuilding, and has now had railway sidings laid into it.

THE NEW SWITCHGEAR CONSTRUCTION COMPANY, LIMITED, have appointed Mr. F. H. Morley, of Star Buildings, Northumberland Street, Newcastle-on-Tyne, as their representative for the Newcastle district.

THE partnership heretofore subsisting between Messrs. J. Smith, R. J. Williams, C. F. Pougher, and T. E. Pougher, carrying on business as the Mechanical Specialities Company, at Richard Street, Birmingham, has been dissolved.

THE partnership heretofore subsisting between Messrs. J. Clark and J. A. Clark, carrying on business as engineers, ironfounders and millwrights, at 76, Cranmer Street, Liverpool, under the style of Clark & Martin, has been dissolved.

MR. GEORGE ELLISON, manufacturing electrical engineer, has removed his head office and works to Wellhead Lane, Perry Barr, Birmingham. The London office has also been removed, the future address being 25, Victoria Street, Westminster, S.W.

MR. J. V. SHERRIN and the Improved Casting Syndicate, Limited, have made an application for the restoration of the patent granted to Mr. Sherrin for an invention entitled "Process of and apparatus for making castings in steel, brass, phosphor bronze, and other materials," numbered 4,387, of 1911.

THE SUCCESSORS TO THE OTTO COKE OVEN COMPANY, LIMITED, has just been registered with a nominal capital of £100,000 in £1 shares, to acquire (by permission of the Board of Trade) part of the undertaking of the Otto Coke Oven Company, Limited, and to carry on the business of constructors of coke ovens. The first directors are Mr. J. A. Christie, Mr. E. D. Simon, Mr. W. Hawdon, and Mr. A. Stanley.

BALDWINS, LIMITED, and the Brymbo Steel Company, Limited, have taken up leases of a large tract of land for the purpose of developing the Oxfordshire ore lands north-west of Banbury. It is proposed to construct a railway to connect the workings with the Great Western Railway at a point some two miles north of Banbury, somewhat beyond the Great Central Junction. The area includes the villages of Hanwell, Drayton, Wroxton, Balscote, Alkerton, Hornton and Horley. The companies' engineers have been for the past week laying out the route of the railway line from Hardwick Farm through Hanwell into Ragnell Bottom.

THE Army Council have applied Defence of the Realm Regulation 30A to the articles of war material mentioned below :—Arms and ammunition : Ammunition, bombs, cartridges, detonators, fuses (for shells), gaines, grenades, guns (artillery), machine guns, mortars, pistols, revolvers, rifles, shells and shell bodies (machined), and cavalry swords. Machinery, raw material, and components other than those mentioned are not included under war material. Application for licence to negotiate or deal in any of the above should be addressed to the Secretary (M.I.6.D.), War Office. No licence is required for rough castings or unmachined shell bodies.

A NEWCASTLE and North-East Coast Branch has been formed in connection with the Federation of British Industries. Good progress has been made with the general movement, which now embraces 422 firms and 62 associations. The N.E. Coast is represented by such concerns as Sir W. G. Armstrong, Whitworth & Company, Limited, Bell Bros., Limited, Bolckow, Vaughan & Company, Limited, the Cargo Fleet Iron Company, Limited, Clarke, Chapman & Company, Limited, the Cleveland Bridge and Engineering Company, the Consett Iron Company, Limited, Cookson & Company, Limited, the Cowpen Coal Company, Limited, Dorman, Long & Company, Limited, R. & W. Hawthorn, Leslie & Company, Limited, the North Eastern Marine Engineering Company, Limited, Palmers Shipbuilding and Iron Company, Limited, Pease and Partners, Limited, and many others. The Newcastle headquarters are at Bolbec Hall.

THE PENARTH PONTOON AND SHIP REPAIRING COMPANY, LIMITED, propose to oppose the suggested shipbuilding scheme at Cardiff. The Cardiff City Council, which favours the scheme, has received a letter from the solicitors for the promoters, stating that they were given to understand that strenuous opposition has been put forward to the scheme by the Penarth Company; "that under a clause in their lease they can prevent the railway company from granting the desired lease to our clients." The solicitors asked the assistance of the Council in removing whatever opposition there might be to the scheme. The promoters state that the enterprise will be confined to shipbuilding alone, and that no ship-repairing work will be undertaken. Fears of competition in the ship-repairing line are therefore removed. It is understood that the Taff Vale Railway Company have expressed their willingness to lease the land required for the shipbuilding yard upon reasonable terms. The proposed site lies between the Penarth Slipways and the Windsor Slipways.

MR. WATT asked the Minister of Munitions on June 28 how many scrap-metal merchants in Glasgow had received exemption cards for their staffs, and of how many did their exempted staffs consist, and how many were of military age; were the cards given to the staff over and above exemptions given to partners; were the cards given to them as departmental managers; and would he say what was the annual turnover of his Department with Glasgow scrap-metal merchants. MR. KELLAWAY : Nineteen scrap-metal merchants in Glasgow have received protection certificates for certain of their employés of military age. Inquiry is being made into the numbers of the staffs of the firms in question, and the proportions of military age as compared to the numbers of exemptions given. No exemption is given to departmental managers unless they are over the age of twenty-five, and have already had ten years' experience of the trade. It is not possible to give the precise total of the turnover of scrap metal with the department, but I may say the turnover has been very large, especially with regard to steel from ships.

IN his presidential address at the annual meeting of the Society of the Chemical Industry at Birmingham, last month, Dr. Charles Carpenter pleaded for the com-

plete and sympathetic collaboration of chemist and engineer, without which, he said, progress in applied science and chemical science, so essential for the future welfare of the Empire, was impossible. He urged as a preliminary step the compulsory teaching in all primary schools of the first principles of experimental science to be supplemented in continuation schools and afterwards at the University. In the past the nation's youth had been developed as unscientifically as the coal resources. The importance of our chemical industries in the scheme of national defence and national progress was at last becoming understood, and must be considered in re-fashioning our educational system. It was also essential that the State should map out all our mineral resources, that they might be placed at the disposal of industry under State control.

Among the industrial undertakings which have recently changed hands is the Low Moor Company, a concern which was established in 1789. In 1914 the chief proprietors, for family and other reasons, decided to dispose of their interest in the company, and this was acquired by a group associated with a number of similar concerns. It is the intention of the new administration to instal additional machinery and plant and to introduce the most up-to-date methods. The share capital of the company remains unaltered at £300,000. The directors are Mr. R. W. Wickham, Royds Hall, Low Moor, Bradford, director of the Lancashire and Yorkshire Railway Company (chairman and managing director); Sir J. S. Harmood Banner, M.P., Aston Hall, Preston Brook, near Warrington, chairman of the Pearson and Knowles Coal and Iron Company; Mr. H. E. Carter, "Grymsdyke," Princes Risborough, director of the Darlington Forge Company; Mr. Robert Miller, of Hoare, Miller & Company, merchants, Pinners Hall, Austin Friars, E.C.; and Mr. Seth Smith Somers, of Walter Somers & Company, Limited, Haywood Forge, Halesowen.

The official "Gazette" of June 29 contained a new regulation as to admission to shipbuilding yards. From July 1, says the regulation, it shall not be lawful for any person, being the owner of a ship or employed as a ship's agent, shipbroker or ship's husband, or as an inspector or surveyor of ships or their machinery, if he is not a natural born British subject, or if his father is or was at any time the subject of a State at war with his Majesty, to enter or be upon any shipbuilding yard without permission in writing of the Admiralty or Army Council, and it shall be the duty of the occupier of every shipbuilding yard to take such steps as may be practicable to prevent the admission to his shipbuilding yard of any such person, save upon the production of such permission as aforesaid. If any such person enters or is in or upon a shipbuilding yard without such a written permission, or if the occupier of a shipbuilding yard fails to take such steps as aforesaid, or if any officer, servant or agent of the occupier fails to comply with any directions given by the occupier for the prevention of the admission of such persons, he shall be guilty of a summary offence against these regulations.

In regard to the controversy on the subject of the British standards, weights and measures v. the metric or decimal system, Messrs. Scott Armstrong & Company write that now the London Chamber of Commerce, the Decimal Association, and kindred institutions, have submitted their case for abolishing the existing British coinage, weights, and measures in favour of the metric or decimal system, it should be pointed out that there is a large body of responsible opinion which is strongly opposed to such a change. It is not contended that the maintenance of the existing British system does not involve certain disadvantages to the user, though they are almost entirely restricted to foreign commerce. The difficulties involved in such a course are admitted to be great, even by those who advocate the change. The cost to the nation would be enormous, and, while involving all businesses, would benefit mainly the largest and those engaged in foreign trade. The time necessary to bring into operation so far-reaching a revolution would be considerable. On the conclusion of peace, trade, and especially foreign trade, will call for the highest energies of this country, and the nation which is most ready to resume foreign commerce will stand to gain proportionately. To select such a time as this for inaugurating so far-reaching a change, with its inevitable scrapping of our existing system of book-keeping, weights, and measures, would be an act of doubtful wisdom, even if the ultimate necessity could be proved up to the hilt, and there were no alternative course to adopt.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Adaptable Moulding Machine Company and O'Keefe, W. M. Foundry moulding-machines. 9,106. June 26.
Barfield, E. P., and Wild, L. W. Furnace for hardening steel, etc. 9,169. June 26.
Barfield, E. P., and Wild, L. W. Indicating condition of steel, iron, etc., during heat treatment. 9,170. June 26.
Beardmore, C. Brass-ingot moulding-machine. 10,133. July 13.
Cooper, B. W. Crucibles, etc. 9,718. July 5.
Cornthwaite H. and S. Treatment of pig-iron. 9,595. July 5.
Crittall Manufacturing Company. Electric furnaces, and method of working same. 9,584. July 3.
Etchells, H., and Greaves, H. A. Method of converting iron ores directly into steel. 8,366. June 12.
Fennell, W. Manufacture of iron and steel and alloys thereof. 9,971. July 10.
Inman, C. R. Gas-heated, etc., furnaces for heat treatment of metals, etc. 10,064. July 12.
Ionides, A. C. Furnace temperature regulation. 8,623. June 15.
Lancey, H. T. Crucible furnaces. 9,756. July 5.
Mallard, A. M. Alloy or solder for aluminium soldering. 9,042. June 23.
Norwich Components, Limited, Williams, R. N., and Scott, W. H. Process and composition for treating cast iron, etc., to prevent rusting thereof, and apparatus for applying composition. 9,439. June 30.
Price, C. F. Crucible furnaces for melting brass, etc., for casting. 9,999. July 11.
Primrose, H. S. Electric furnaces, and method of working same. 9,584. July 3.
Rappez, N. Moulding-machines. 10,035. July 11.
Rollason, A. Combined tilting and reversible open-hearth melting-furnace and converter. 8,653. June 16.
Rollason, A. Use of mill scale, etc., in manufacture of steel. 9,998. July 11.
Sahlin, O. Electric furnaces. 8,478. June 13.
Stokes, F. W. Casting-machines. 9,005. June 22.
Turner, W. L. Manufacture of rustless or stainless, etc., steel. 8,782. June 19.
Turner, W. L. Manufacture of ferro-chromium. 8,813. June 19.
Walker, J. H. Cores for moulding hollow bodies. 8,407. June 12.
Whiteley, J. T. Apparatus for casting hollow metal ingots. 9,419. June 29. (United States, November 19, 1914.)
Whyte, S. Purification of iron. 10,234. July 14.
Whyte, S. Production of hard cast-iron articles. 9,297. June 28.

Sale of Machine Tools.

The Minister of Munitions has withdrawn the Order applying Regulation 30A of the Defence of the Realm Regulations to machine tools and machinery driven by power suitable for cutting, stamping, or working metal, and the general permit for purchasing or entering into negotiations for the purchase of machine tools issued on August 28, 1916, except in so far as they relate to insurance.

All applications for a permit to purchase or enter into negotiations for the purchase of the war material referred to in the Order should be made to the Executive Officers of the Area Clearing House Boards, whose addresses may be obtained upon application to the Director, Central Clearing House, Ministry of Munitions, Charing Cross Buildings, W.C.2.

No new or second-hand machinery can be purchased, hired, or transferred from the premises where it is at present located without the sanction of the Ministry of Munitions. No applications will be considered for the release of Machine Tools, whether new or second-hand, for class "C" work, or work not essential to the conduct of the war.

Pig-Iron Prices.

Modification of General Permit.

With reference to the Order made by the Minister of Munitions on July 7, 1916, applying Regulation 30 (A) of the Defence of the Realm Regulations to war material consisting of certain classes and descriptions of metallurgical metal, coke, pig-iron and steel, and to the General Permit for dealing in such war material issued by the Minister of Munitions on November 1, 1916, the Minister of Munitions has now issued an Order dated July 17, 1917, and giving notice—

(1) That the said General Permit is modified by the insertion of the Schedule thereto of the following prices for the articles hereunder specified in addition to, or, where such articles are already specified in such Schedule, in substitution for the prices contained in such Schedule.

Maximum Prices for Pig-iron Above Referred to.

HEMATITE PIG-IRON—MALLEABLE.

REFINED.	Per ton net f.o.t. makers' works. £ s. d.
Refined cupola cast	8 0 0
Refined cupola cast to guaranteed analysis	8 5 0
CAST DIRECT FROM BLAST FURNACES.	
Small pig-iron—all grades	7 10 0
Medium pig-iron, white to grey mottled	7 5 0
Medium pig-iron, all other qualities	6 17 6
Large pig-iron, all grades	6 17 6

All the above prices include agents' commission or merchants' profit, which is not to exceed 5s. per ton.

Applications for licences to sell special grades of extra quality at special prices will be separately considered by the Director of Steel Production.

CLEVELAND PIG-IRON.

	Per ton net f.o.t. makers' works. £ s. d.
Basic	4 17 6

SOUTH STAFFORDSHIRE, SHROPSHIRE, AND WORCESTERSHIRE PIG-IRON.

	£ s. d.
Basic	4 17 6

All the above additions to the Schedule of the General Permit are to take effect from the date of this notice, and none of such additions shall be deemed to prejudice or to interfere with the carrying out of any contract in writing for sale or purchase of the above-mentioned war material entered into prior to such date at prices lawful at the date of such contract.

Substituted Price.

CLEVELAND PIG-IRON.

	Per ton net f.o.t. makers' works. £ s. d.
No. 1.	4 16 6
Other grades	4 12 6

SOUTH STAFFORDSHIRE, SHROPSHIRE, AND WORCESTERSHIRE PIG-IRON.

	£ s. d.
"Part-mine" forge	5 0 0
"Part-mine" foundry...	5 2 6

The above substituted prices shall take effect from April 2, 1917.

(2) That in further modification of the said General Permit, in all districts an extra charge of 1s. per ton may be charged over the fixed maximum price for basic pig-iron cast in chills.

Deaths.

THE death is reported of Mr. J. Benson, ironfounder, Pontardulais.

THE death is reported of Mr. Henry Crisp, iron founder, of Bradford-on-Avon, at the age of 69 years.

MR. W. F. CRAVEN, foundry manager to Pollit & Wigzell, Limited, Sowerby Bridge, died recently, aged 80 years.

MR. W. MOULTON, a departmental manager of Ransomes, Sims and Jefferies, Ltd., Orwell Works, Ipswich, died recently.

THE death took place on July 1 of Mr. W. Wood, of Burnbrae, Falkirk, a director of the Callendar Iron Company, Limited, aged 81 years.

THE death has taken place at Darlington of Mr. R. Blake, the well-known Sunderland and Tyneside engineer and machinery merchant. Mr. Blake was in his eighty-first year.

CAPT. H. COLES, Sherwood Foresters, who has been killed in action, was 39 years of age, and the eldest son of Mr. H. J. Coles, of the firm of H. J. Coles, Limited, crane manufacturers, Derby.

LIEUT. C. C. WATSON, R.F.A., eldest son of Mr. C. Watson, of Wood View, Leek, Staffordshire, died of wounds on June 1. He was a director of the Johnson Fireclay Company, Limited, Cliff Vale.

THE death occurred at Harrogate last week of Major W. H. Holden, of Ulverston, one of the oldest employés of the North Lonsdale Iron & Steel Company, Limited. For many years he was head of the sales department.

THE death is announced at Birkdale of Mr. A. Chapman, a director of the Liverpool engineering firm of Fawcett, Preston & Company, Limited. The deceased gentleman, who was in his 79th year, had been associated with the company for over sixty years, having joined as an apprentice.

THE death is announced from Bochum, Germany, at the age of 62 years, of Dr. Ing. Fritz Baare, the general director of the Bochum Verein, für Bergbau und Gusstahlfabrikation. The deceased, who was an authority on the design and construction of hydraulic forging presses, received part of his early training in Leeds.

THE death is announced from Cincinnati, U.S.A., at the age of 69 years, of Mr. William Lodge, head of the Lodge and Shipley Machine Tool Company, of that city. The deceased, who was born in Leeds, England, was one of the leaders of the American machine tool industry and a Past President of the United States National Machine Tool Builders' Association.

CAPTAIN RONALD LINDSAY JOHNSON, R.F.A., killed in action, was the youngest son of the late Mr. William Henry Johnson. In 1912 he went to Australia and entered the branch office in Sydney of the firm of R. Johnson, Clapham & Morris, Limited, with which his father was long connected as chairman and managing director. On the death of his eldest brother, Captain W. Morton Johnston, Captain Ronald Johnson was elected chairman of Messrs. R. Johnson, Clapham & Morris, and held that position at the time of his death.

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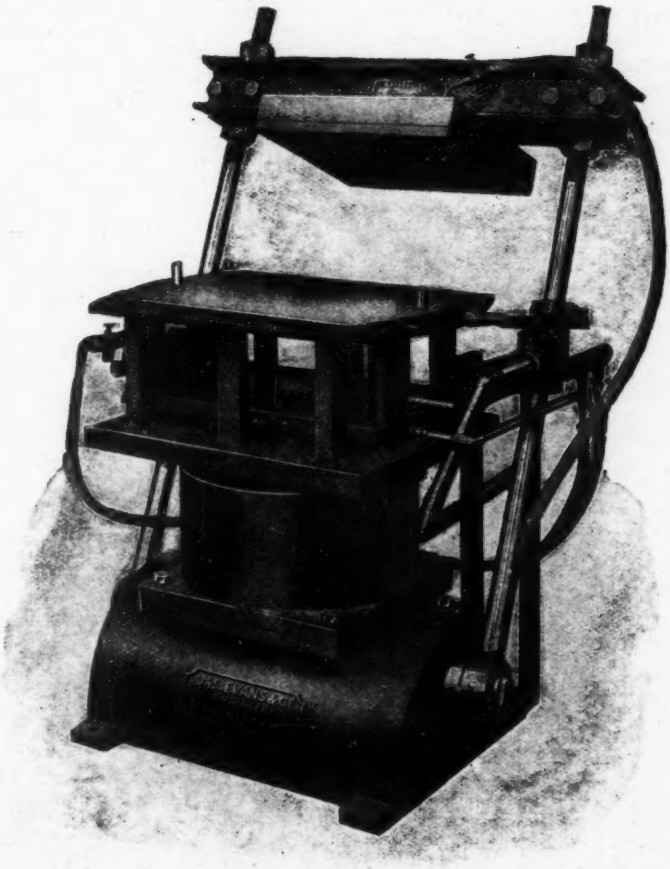

JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

Personal.

MR. R. LEADER has been elected a director of Davy Bros., Limited.

DR. W. RIPPER has been elected Dean of the new Faculty of Engineering at Sheffield University.

THE late Mr. John Jefferies, engineer, of The Hermitage, Shirehampton, Bristol, left £35,961.

MR. J. S. NETTLEFOLD, owing to ill-health, has resigned his seat on the board of Kynoch, Limited.

MR. D. C. LYSAGHT has been elected a director of John Lysaght, Limited, to fill one of the vacancies on the board.

THE gross value of the estate of the late Mr. Robert Colver, of Jonas & Colver, Limited, Sheffield, is £243,530.

SIR ROBERT HADFIELD was recently admitted to the freedom of the City of London through the Goldsmiths' Company.

MR. G. BOOTHEWAY has been elected a director of Howard & Bullough, Limited, in place of Mr. A. Hitchon, resigned.

THE late Mr. T. Campbell, chairman of Shaw (Glasgow), Limited, Mary Hill Ironworks, Glasgow, left estate valued at £42,166 gross.

MR. ALBERT SENIOR, of George Senior & Sons, Limited, Ponds Forge, Sheffield, has been appointed Swedish Vice-Consul in Sheffield.

SIR JAMES B. MARSHALL, director of dockyards since 1906, has been elected deputy chairman of J. Samuel White & Company, Limited, of Cowes.

MR. GERALD STONEY, F.R.S., has been appointed professor of mechanical engineering at the Manchester School of Technology, in succession to Professor Field.

THE late Sir Benjamin C. Browne, for many years chairman of R. & W. Hawthorn, Leslie & Company, Limited, left estate of the value of £77,415, of which £76,812 is net personalty.

MR. J. W. JOHNSON, for many years a representative of Cammell, Laird & Company, Limited, and late manager of their Newcastle agency, died suddenly at Sunderland on June 28, aged 50 years.

MR. E. J. FOX, who has resigned his position of London manager of Stewarts & Lloyds, Limited, to become general manager and managing director of the Stanton Ironworks Company, Limited.

MR. L. CHAUVIN has resigned his seat on the board of the King's Norton Metal Company, Limited, in consequence of his absence abroad in the Army, and has been succeeded by Mr. H. McGowan.

MR. J. CALDERWOOD, who has relinquished the position of manager at the Cleveland Steel Works of Bolckow, Vaughan & Company, Limited, has been the recipient of a presentation from the officials and workmen.

THE death is announced at the advanced age of 89 years of Mr. J. Dodgson, cashier of the Parkgate Iron & Steel Company, Limited. The deceased had been associated with the undertaking since he was fourteen years of age.

MR. W. W. MAY has just retired from the position of engineer works' manager of William Beardmore & Company, Limited, Dalmuir, after 26 years' service with the firm. He has been the recipient of a presentation from the officials and men.

THE late Mr. R. Colver, J.P., a director of Jonas & Colver, Limited, Continental Steel Works, Sheffield, and chairman of J. and G. Wells, Limited, of the Eckington Colliery, left estate of the gross value of £243,530, of which £231,831 is net personalty.

PROFESSOR J. O. ARNOLD, Professor of Metallurgy at the Sheffield University, has been appointed Dean of the new Faculty of Metallurgy at that University. This is the first recorded instance of any University in the world creating a Faculty of Metallurgy.

SECOND-LIEUT. A. I. E. HAWKS, R.F.A., who has died from wounds received in action, was the only son of Mr. A. E. Hawks, works manager for Babcock & Wilcox, Limited, Renfrew. When war broke out, the deceased officer was with the firm as an apprentice.

PROF. RICHARD AKERMAN, the well-known Swedish metallurgist, celebrated his eightieth birthday a few weeks ago. It is half a century ago that he visited the United States and wrote for the Jernkontoret a thesis on the prospects of Swedish iron in the United States.

Legal.

Debts to Enemy Firms.

In the King's Bench Division on June 22, Mr. Justice Atkin delivered judgment on the right of a controller appointed under the Trading with the Enemy Amendment Act, 1916, to sue for debts due to an enemy firm. The action was brought by the controller of Messrs. Continho Caro & Company, metal merchants, of Fenchurch Street, E.C., against Messrs. Vermont & Company, of Cullen Street, E.C., to recover £1,427, the price of goods sold and delivered. It appeared that an action was commenced against the defendants for the amount due for goods supplied. The defendants admitted they received the goods, but contended that the plaintiffs were an enemy firm within the meaning of the Proclamation against trading with the enemy, and that they could not bring an action. His Lordship, in giving judgment, said the object of the appointment of the controller was to realise assets and pay the non-enemy creditors, and it occurred to him to be essential that there should be vested in the controller power to sue the defendants. If there was no such power the debts would remain uncollected, creditors would not be paid, and the winding-up would be incomplete. Thus, the object of the Act would be defeated. In his opinion, the action would lie, and he gave judgment for the sum claimed, with costs.

Vickery's Patents, Limited v. H. and J. Hill.

In the King's Bench Division, recently, before Mr. Justice Low, Vickery's Patents, Limited, claimed damages from Messrs. H. & J. Hill, of Willenhall, Staffordshire, sub-contractors, for breach of a contract for the supply of castings, alleging arrears of deliveries and defects in castings supplied. Defendants denied defects, and pleaded, alternatively, that it was not their duty under the contract to see if there were defects. Further, they pleaded the contracts were made subject to a custom that machinists had no claim against founders in respect of castings otherwise than to return them. Defendants had accepted cancellation of the contract, and counter-claimed for £1,322 for grenades delivered. Counsel said that plaintiffs, who were supplying 75,000 grenades a week, had so framed the contract as to put responsibility for inspection on the sub-contractors. The hearing was adjourned.

In giving judgment later his Lordship held that there had been a breach of the obligation to deliver the castings free from sand, and gave judgment for plaintiffs for £1,254, with costs.

Robinson v. Birks & Lockwood.

At the West Riding Assizes, on July 18, before Mr. Justice Coleridge, Mr. J. A. Robinson, a Sheffield steel merchant, was the plaintiff in an action brought against Birks & Lockwood, Limited, steel manufacturers, Sheffield, to recover damages for non-delivery of high-speed steel. It was explained on behalf of the plaintiff that in June, 1915, he entered into a contract with the defendants to purchase 5,000 kilos of high-speed steel at 11d. a lb., plus 10 per cent. After a delivery of a small quantity of the goods the defendants refused to make further deliveries. In the meantime, the price of high-speed steel had gone up considerably.

The defence was that the conditions of the contract had not been fulfilled, and that the contract had been rescinded by mutual agreement.

Mr. Justice Coleridge, after hearing the evidence, said he was persuaded that there had been no rescission of the contract by mutual consent, and he gave judgment for the plaintiff for the amount claimed, £270, with costs.

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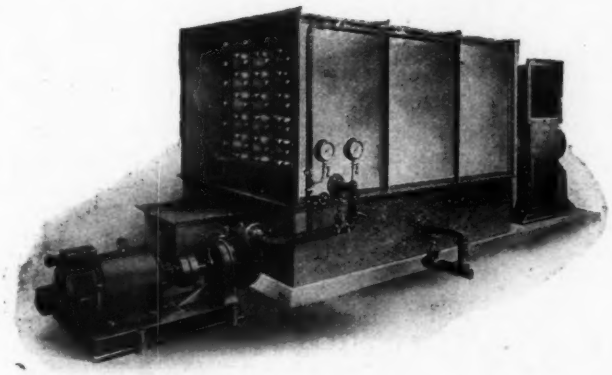

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☛ IF YOU HAVE DIFFICULTIES WITH YOUR SPECIAL CASTINGS CONSULT US.

We can put you right.

New Companies.

Marine Metal Company, Limited.—Capital £10,000 in £1 shares.

Brough Lead Company, Limited.—Capital £20,000 in £1 shares.

K. W. P. Engineering Company, Limited.—Capital £5,000 in £1 shares.

Blackwall Engineering and Welding Works, Limited.—Capital £3,000 in £1 shares.

Hutchinson's Testing Apparatus, Limited.—Capital £500 in £1 shares. Registered office:—11, Tothill Street, S.W.

Ferro-Concrete Ship Construction Company, Limited.—Capital £30,000 in £1 shares. Registered office: 4, St. Mary Axe, E.C.

Du Croo & Brauns, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office: 53, Victoria Street, S.W.

Dublin Dockyard (War Munitions) Company, Limited. — Capital £20,000 in £1 shares, to acquire the business carried on at 15a, East Wall, Dublin.

Deutsch & Brenner, Limited.—Capital £20,000 in £1 shares, to carry on the business of metal merchants. Registered offices: 44, Harford Street, Birmingham.

Macfarlane Winch Company, Limited. — Capital £12,005 in 100 1s. shares and 12,000 £1 shares. The first directors are E. T. L. Williams and G. T. Macfarlane.

J. Marriott & Company, Limited.—Capital £1,500 in £1 shares, to carry on the business of ironfounders, etc. Registered office: 71, Temple Street, Wolverhampton.

Alfred Herbert (Russia), Limited.—Capital £25,000 in £1 shares, to carry on in Russia or elsewhere, the business of dealers in and manufacturers of machinery, machine tools, etc.

Fulham Small Arms, Limited.—Capital £50,000 in 40,000 preference shares of £1 each and 200,000 ordinary shares of 1s. each. Registered office: 620, Lillie Road, Fulham, S.W.6.

Russell Bros. (Redditch), Limited.—Capital £10,000 in £1 shares, to take over the business of engineers carried on by Russell Bros. at Redditch. Registered office: Littleworth, Redditch.

Grove Engineering & Utilities, Limited.—Capital £1,500 in £1 shares. The first directors are A. Maber and Miss T. H. Cole. Registered office: 196, Merton High Street, Wimbledon, S.W.

Guest & Chrimes, Limited.—Capital £150,000 in £1 shares, to take over the business carried on as Guest & Chrimes, at Rotherham Brass Works, Don Street and Main Street, Rotherham.

George L. Flett & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, patternmakers, etc. Registered offices: 107, Reidvale Street, Dennistoun, Glasgow.

Wm. Hume & Company, Limited.—Capital £2,500 in £1 shares, to take over the business of Wm. Hume & Co., coppersmiths and brassfounders, Port Glasgow. Registered office: 10, Scarlow Street, Port Glasgow.

British Basic Slag (Albert's Successors), Limited.—Capital £200,000 in £1 shares. The first directors are:—A. Read, Middlesbrough; L. Chandler, Birmingham. Registered Office: 11, Ironmonger Lane, London, E.C.

Lochside Engineering Company, Limited.—Capital £10,000 in 9,500 preferred ordinary "A" shares of £1 each, and 10,000 deferred ordinary "B" shares of 1s. each. Registered office: 117, Victoria Street, S.W.

Cowper-Coles Aircraft Company, Limited.—Capital £6,000 in 5,000 preference shares of £1 each and 20,000 ordinary shares of 1s. each. The first director is S. O. Cowper-Coles. Registered office: 1, French Street, Sunbury-on-Thames.

Boon Tractors, Limited.—Capital £10,000 in £1 shares, to acquire all the property of J. D. Boon, from the Boon Traction & Agricultural Motors, Limited. The first director is J. D. Boon. Registered office: 28, Coten End, Warwick.

John T. Callaghan & Company, Limited. — Capital £3,000 in £1 shares, to take over the business of engineers. The first directors are J. T. Callaghan, N. Burton, and C. Y. Burton. Registered office: 46, Grosvenor Chambers, Deansgate, Manchester.

George Waller & Son, Limited.—Capital £30,000 in £1 shares, to take over the business of gas, hydraulic and general engineers carried on at the Phœnix Iron Works, Stroud, as George Waller & Sons. The first directors are B. B. Waller, P. G. Waller, and E. F. Hooper.

Reginald Christie & Dickinson, Limited. — Capital £1,000 in £1 shares, to take over the business of a marine engineer, etc., formerly carried on by R. Christie, at 5, Lloyd's Avenue, E.C., as Reginald Christie & Company. The first directors are R. Christie and J. T. Dickinson.

Intensive Machining Company, Limited.—Capital £3,000 in £1 shares, to take over the business of engineers and manufacturers of munitions and aeroplane parts carried on by E. P. J. Pavot and T. N. Bayens. The first directors are A. Ravelli, T. N. Bayens, and E. P. J. Pavot.

Bladen & Company, Limited. — Capital £6,000 in 4,400 preference and 1,600 ordinary shares of £1 each, to take over the business of Bladen & Company, Limited, in liquidation, and to carry on the business of structural engineers, &c. The first directors are: J. H. H. Horsfield, J. Horsfield, and J. Coubrough. Registered office: Parkhead Gilder Works, Glasgow.

Tudor & Onions, Limited.—Capital £4,000 in £1 shares, to take over the business of iron and machinery brokers carried on by J. H. S. and C. H. Onions, C. H. Nock, and H. Grice as Tudor & Onions, at Great Bridge, W. Bromwich. The first directors are J. H. Onions (managing director) and S. Onions. Registered office: Sheepwalk Lane, Great Bridge, Tipton, Staffs.

William West & Sons, Limited.—Capital £20,000 in £1 shares, to take over the business of a metal manufacturer and metal roller, carried on at 16, Caroline Street, Birmingham, by W. West, and the business carried on at the Globe Works, Cliveland Street, Birmingham, by William West & Sons. The first directors are W. West (permanent chairman and managing director), E. S. West, and A. V. West. Registered office: 16, Caroline Street, Birmingham.

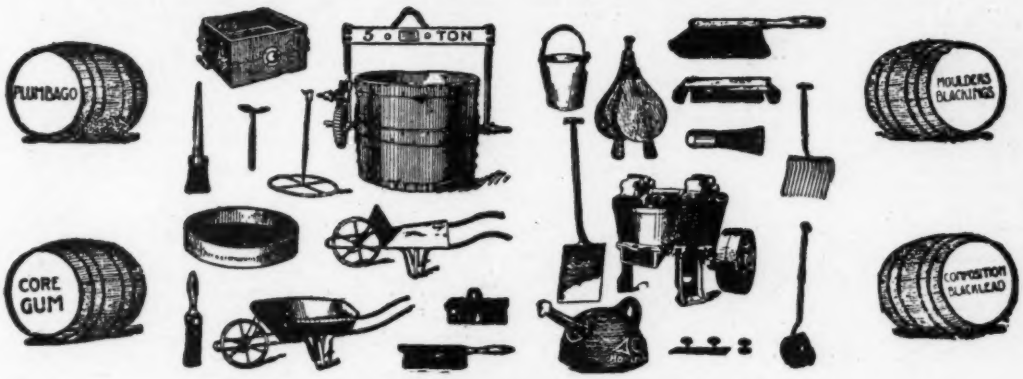
CEMENT JOINTS FOR CAST-IRON WATER MAINS.—Long Beach, in the U.S.A., now has 60 miles of cast-iron water mains, ranging from 4 to 24 in. diameter, and laid with cement joints. All these pipes are under pressures ranging from 40 to 80 lbs. per sq. in. Mr. Clark H. Shaw, in a Paper recently presented to the American Society of Civil Engineers, described the method of making these joints. He recommends the use of dry jute, free from oil or grease, instead of oakum for the foundation ring. The Portland cement is to be placed dry on a piece of canvas (a torn sack) under the joint, and to be moistened and mixed to a consistency so that when gripped firmly in the hand the paste should retain its form, but crumble if dropped from a height of 12 in. The paste is then to be hand-packed into the joint, and to be hand-rammed with a caulking tool until the socket is half full. The joint is then to be filled and caulked with an iron tool and heavy blows with a hand-hammer, until the cement is thoroughly packed, and the packing to be continued till the joint is nearly full. A small bead of neat cement in plastic condition is then put on, using the caulking tool for smoothing like a trowel. After the cement has set, the joint is to be covered with earth, so as to protect it from the air and sun. The back filling of the excavated material is to be settled with water. About 20 per cent. of the cement is generally wasted. The joint is allowed to stand 48 hours before the pressure is turned on. It is stated that such cement joints will stand a great deal of rough treatment, and that settlements to the extent of 3 in. and more have occurred without destroying the seal. As regards cost, according to the written communication of another member a cement joint is cheaper than a lead joint, but more expensive than one made up with "leadite."

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



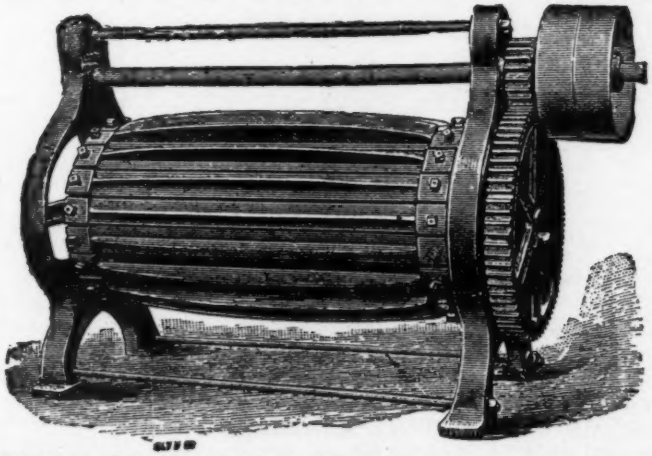
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
" " 0.02 "	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
" " 0.02 "	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
" " 0.02 "	7	0	0
HEMATITE—MALLEABLE—			
Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
" other grades	4	7	6
" basic	4	17	6
Northamptonshire, forge	4	7	6
" fdy numbers	89/0		94/0
" basic	4	17	6
Derbyshire, forge	4	10	0
" foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
" " foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
" " foundry	4	17	6
" " basic	4	17	6
South Staffordshire—			
Part mine forge	4	15	0
" foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
" foundry	6	0	0
Warm air forge	7	5	0
" foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works.
Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	5d.
Bar Ends	6d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless..	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	25	0	0
" export £36 0 0—39	0	0	

* F.o.b. Liverpool.

Non-Ferrous Metals.

	£	s.	d.	£	s.	d.
Copper.						
Standard, Cash	125	0	0	125	10	0
Three months	124	10	0	125	0	0
Electrolytic ..	137	0	0	133	0	0
Tough ..	135	0	0	131	0	0
Best selected ..	135	0	0	131	0	0
Tin.						
Standard, Cash	243	5	0	243	10	0
" Three months	240	0	0	240	5	0
English Ingots ..	—			239	10	0
Bars	—			240	10	0
Refined	—			—		
Spelter.						
American	54	0	0	50	0	0
Specials..	—			—		
Hard	—			—		
British	—			—		
Lead.						
Soft Foreign	30	10	0	29	10	0
English	—			Nom.		
Antimony.						
Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton — —

Phosphor Bronze.

	Per ton.
INGOTS.	
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
" Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper .. 35/- above price of best selected copper.
15 per cent. Phosphor Copper .. 40/- above price B.S.
Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.
(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FARELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**

98/99% purity, per lb. — —

***Nickel.**

In cubes, 98/99% purity Per ton —

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
" rolled to spoon size ..	—

***Tungsten Metal Powder.**

96/98% purity.. per lb. .. —

***Molybdenum Metal.**

96/98% purity.. per lb. .. —

***Cobalt Metal.**

97% purity .. per lb. .. —

Quicksilver.

75 lb. bottle .. .. .. —

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	s.	d.	s.	d.
Cleveland.				
Steel scrap, heavy melting..	105	0	—	
Iron scrap cast (cupola metal)	90	0	95	0
London (f.o.b.).				
Heavy steel			100	0
Light "			55	0
Heavy cast			95	0
Control Prices.				
Heavy Steel Melting Scrap	105	0	125	0
Turnings and Borings			50	0
Wrought Iron Scrap ..	105	0	125	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	—		
Hy. Selected Scrap Brass ..	—		
Hy. Tinned Copper Wire	—		
Best Selected Gunmetal Scrap ..	—		
Re-melted Ingot Lead	—		

Stocks.

	Tons.
Metals.	
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	—

Coke.

	s.	d.	s.	d.
Middlesbrough.				
Gas Coke	31	0	—	
Glasgow.				
Foundry Coke	—		42	0
Furnace Coke	30	0	—	
Gas Coke	—			
London.				
Welsh or Durham Foundry, d/d London Stations in truck	45	6	53	0
Ditto, d/d Birmingham Stations	44	0	46	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6	—	

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	28	0
" foundry	30	6
South Yorkshire, West Yorkshire, Lancashire, Staffordshire and Midland Counties blast furnace	25	8
South Wales blast furnace ..	30	0
" foundry	43	0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

MOULDERS (General) and COREMAKER required immediately for Government factory. Experienced men used to high-class petrol motor work; good wages and prospects, war bonus and overtime. No man on Government work can be engaged.—Apply your nearest Employment Exchange, mentioning this paper and No. A3341.

FOREMAN for Foundry, practical man, used to loam and other castings; good disciplinarian; Government work.—MONOMETER MANUFACTURING CO., Whitehouse Street, Aston; or Albion Foundry, Browning Street, Ladywood.

WANTED, FOUNDRY FOREMAN for Brass Foundry producing large quantities brass bar and billets. Must have good control of men.—Apply, in first instance, by letter, stating experience and qualifications, to 252, SELL'S ADVERTISING OFFICES, Fleet Street, London, E.C.4.

FOUNDRY MANAGERS, PLEASE NOTE.—Odd sides to register, made in plaster, are heavy or cost pounds; but by using rough wooden box parts and Turner's Patent Sockets, they will cost shillings.—TURNER, 28, Plumpers Road, Sheffield.

FOUNDRY SUPERINTENDENT Wanted for large Aluminium Foundry on Government work. Must have good practical experience, including Machine Moulding, be good organiser, and able to control men. Good salary and commission to right man—permanency. No person already on Government work will be engaged. Give full details as to qualifications, and state age, salary required, etc., to your nearest Employment Exchange, quoting No. A.3414.

FOR SALE AND WANTED.

WANTED, quantities of Brass Foundry FLUE DUST.—Submit samples to HENRY LEVIN WEBB & Co., Sugar House Lane, Stratford, London, E. 15.

10-TON FOUNDRY LADLE, complete with tilting gear; also small Ladle, about 2 ton, 21 in. deep, 2 ft. dia. at top, 20 in. at bottom.—W. BLENKINSOP & Co., Middlesbrough.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply HALL, 26, Paradise Square, Sheffield.

VENTILATING FANS FROM STOCK, 12 in. to 60 in. dia., belt-driven. Electric-driven at few days' notice, depending on current available. Centrifugal Fans for dust and fumes exhausting, smiths' fires, foundry cupolas, New and Second-hand.—SMITH BROTHERS, LTD., Aylestone Park, Leicester.

ONE very strongly-built W.I. Steam Box, about 11 ft. long by about 20 ft. wide by 12 in. deep, fitted with internal steam pipes and three W.I. lids for steaming timber. 40-Ton Steel Metal Ladle, 8 ft. 6 in. dia., 8 ft. deep, firebrick lining, lifting shackles, etc., on portable railway, truck 4-ft. 8½-in. gauge, spare ladle and chains.—RICHARD SIZER, LTD., Cornwall Street, Wilmington, Hull.

FOR SALE AND WANTED.—*cont.*

TWO new 300-lb. Town Gas-Fired CRUCIBLE FURNACES, by J. Wright and Eagle Range, Ltd., Birmingham, for Sale.—Offers to THE METALLURGICAL COMPANY, LTD., Walker Gate, Newcastle-on-Tyne.

FOR SALE.—50-cwt. GEARED LADLE for Sale, in good condition.—Apply WESTERN FOUNDRIES, LTD., Southall, Middlesex.

BLOWING FAN, by Alldays, 12-in. outlet; EXHAUST FAN, cast-iron casing, 10-in. outlet and inlet, F. and L. pulleys; BAKER'S BLOWER, 6-in. outlet; 30-in. New Belt-driven VENTILATING FAN, cheap.—PARKER, Siddals, Derby.

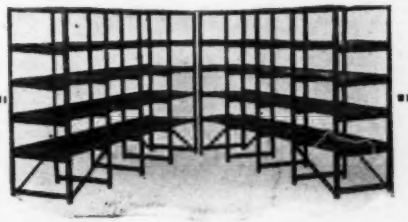
FANS AND BLOWERS.—Enquire from our rebuilt Fan Dept. for your needs before placing order elsewhere.

State clearly the volume and pressure, with brief description of working conditions.

We are always open to purchase approved makes of Propeller and Centrifugal Fans.

PROGRESSIVE ENGINEERING CO., LTD., LEICESTER.

F. L. HUNT & CO.,
FOUNDRY
FURNISHERS
AND
FOUNDRY REQUISITES
Of every description.
56, 58, 60, CHAPEL STREET,
SALFORD, MANCHESTER.



SANKEY
Fireproof Steel Storage Bins
For Workshop and Warehouse
Write for Details.
Joseph Sankey & Sons, Ltd.,
Hadley Castle Works, WELLINGTON, Shropshire.

PLUMBAGO—CRUCIBLES.

Parting Powder.

WILLIAM OLSEN, LTD.,
Cogan Street, HULL.

FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

Wax Core Vent.

GLUTRIN—CORE GUM.

FIRE BRICKS & CLAY
CUPOLA BRICKS.
Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,
(STOURBRIDGE) Ltd.,
STOURBRIDGE.

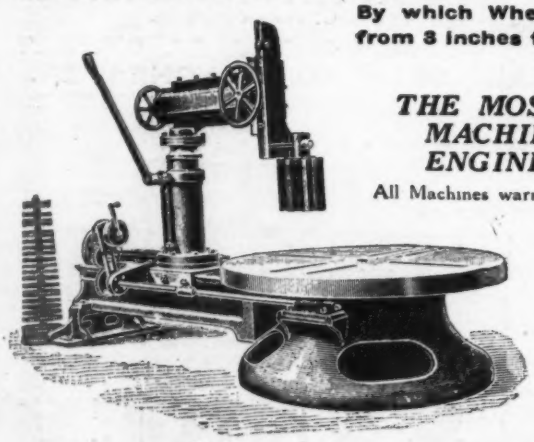
38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

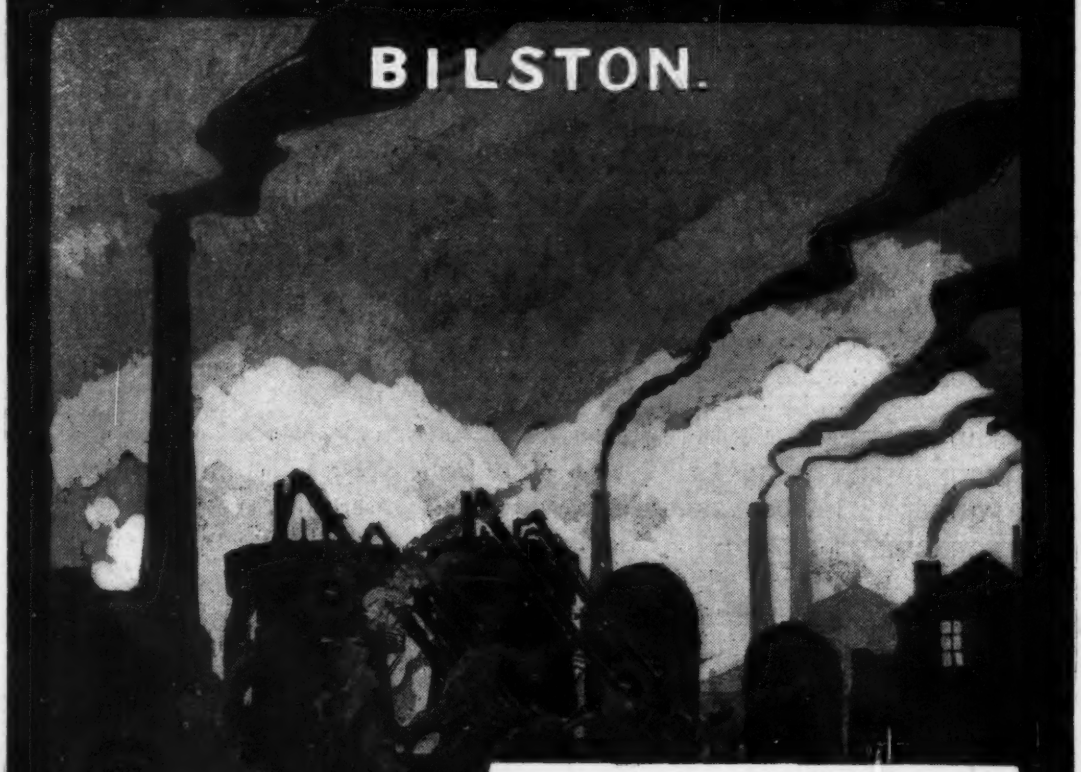
ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, ***OLDHAM.***

CAPPONFIELD

BILSTON.



Special Pig Iron

We can meet your requirements in

SPECIAL

Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
B.C.B.	Cold Blast
ZENITH	Refined

Thomas & Isaac Bradley, Ltd.,

Capponfield Blast Furnaces,

— BILSTON. —

"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

FOUNDRITE SAVES MONEY.

FOUNDRITE PREVENTS WASTERS.

Telegraphic Address—"MOROD, SHEFFIELD." **Telephone 4318.**

HEDLEY MOORWOOD & Co., Ltd.,

21, Church Street, SHEFFIELD.

FOUNDRY EXPERTS.

FOUNDRY CUPOLAS, LADLES,

And the

OSBORN'S PATENT CUPOLA

SPARK ARRESTER

Are the Specialities of

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RAILWAY WORKS, WEST GORTON, MANCHESTER.

ON ADMIRALTY LIST.

Telegrams—"TUYERE, MANCHESTER." Nat. Telephone—No. 70, OPENSHAW.

London Agents: MURPHY, STEDMAN & CO., Ltd., 180, Gray's Inn Road, London, W.C.

FOUNDRY MOULDING MACHINES

For INTRICATE and SIMPLE CASTINGS

For Great Britain: **Send Blue Prints or Sample Castings.**

The UNIVERSAL SYSTEM of MACHINE MOULDING

and MACHINERY COMPANY, LIMITED,

97, QUEEN VICTORIA STREET, LONDON, E.C.

Tele. Ad.: Machimould, London. **(Over 5,000 Machines now running.)** **Telephone: City 2243.**

For Allied and Neutral Countries:

Établissements PH. BONVILLAIN & E. RONCERAY, PARIS.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

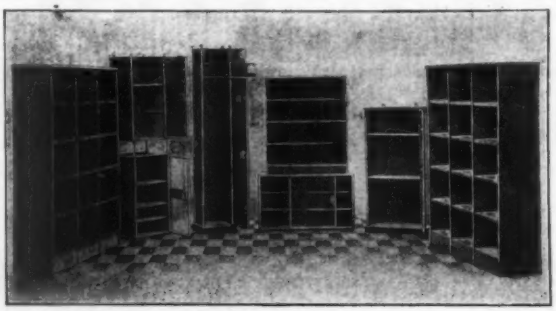
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."



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Steel Shelving, Lockers, Bins, Cupboards, Etc.,

FOR

WORKS, OFFICES, BANKS, AND WAREHOUSES.

JAMES GIBBONS,

St. John's Works, WOLVERHAMPTON.

London Office: Fisher St., Southampton Row.

WE SUPPLY **THE** LEADING FIRMS IN THE TRADE WITH

FOUNDRY BLACKINGS

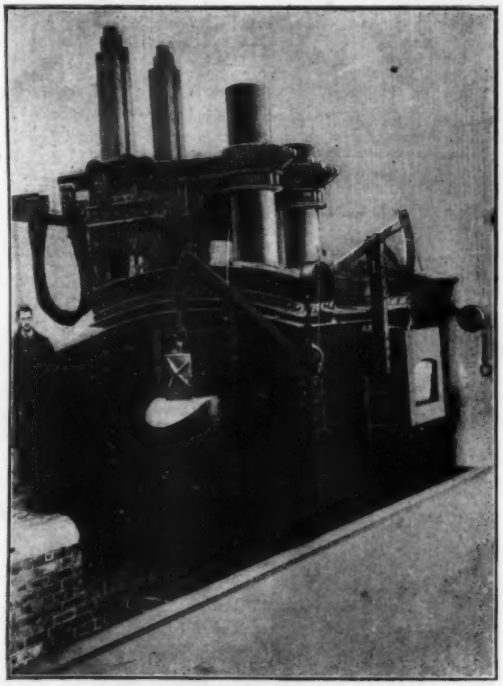
OF ALL KINDS

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

J. & I. WALKER, EFFINGHAM MILLS, ROTHERHAM.

Our Specialite is Studying Special Requirements.

KINDLY HAND US YOUR ENQUIRIES.



3-Ton GREAVES-ETCHELLS Electric Furnace.

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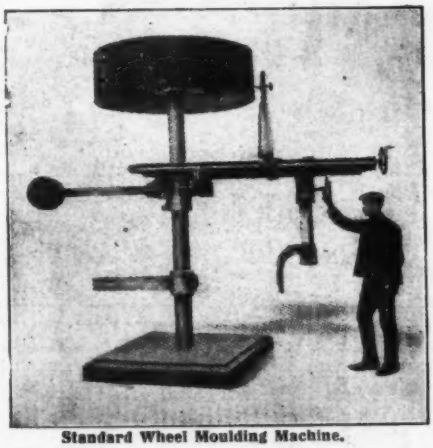

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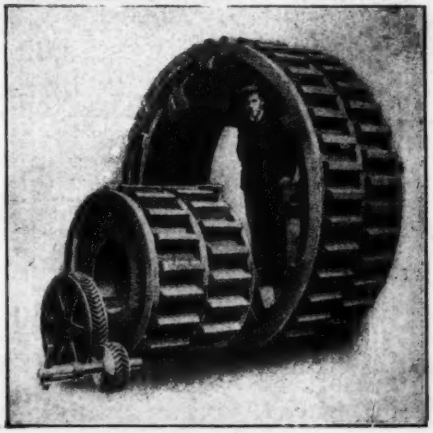

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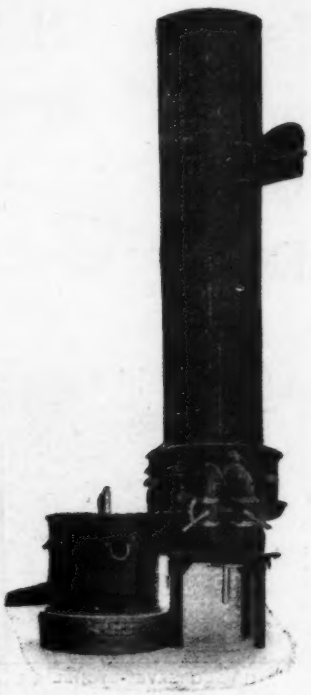

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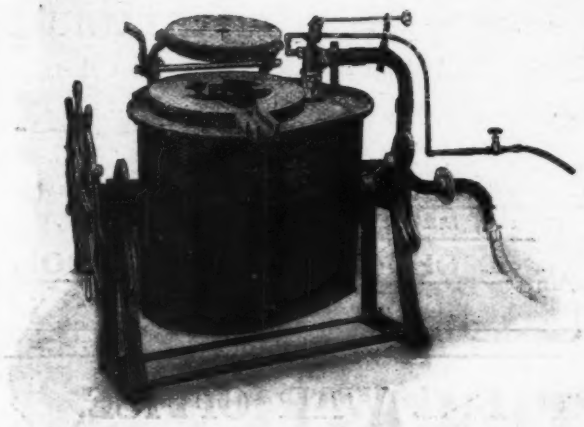

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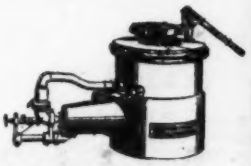

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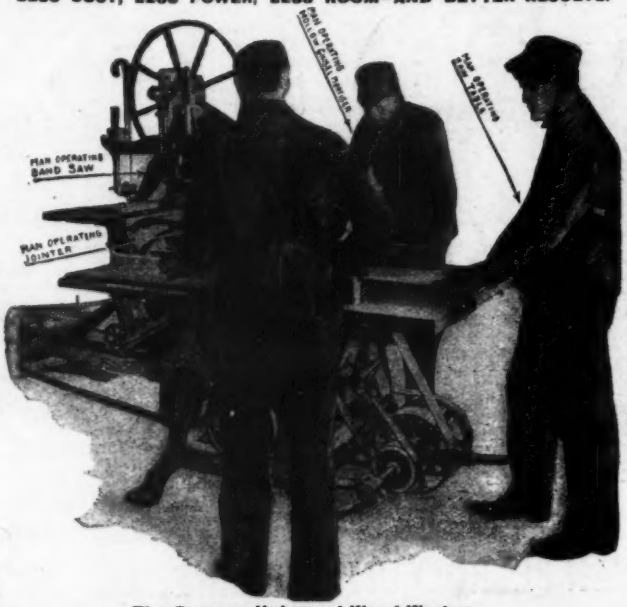

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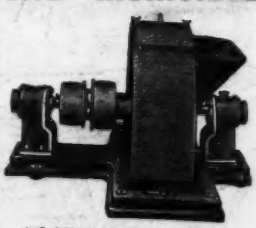

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